Bay Area Regional Intelligent Transportation Systems (ITS) Plan

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Executive Summary

This report is the culmination of work performed under Phase 2 of the San Francisco Bay Area Regional Intelligent Transportation Systems (ITS) Plan and has resulted in the development of the Regional ITS Architecture and ITS Plan. Phase 1 of the project provided an assessment of the current state of ITS in the region, based on an inventory of ITS plans, projects, and activities. Phase 1 essentially set the stage for the development of the Regional ITS Architecture and ITS Plan. The Plan was prepared for the Metropolitan Transportation Commission (MTC), based on input from a broad range of regional stakeholders.

ITS is the use of electronics, communications, and computers in an integrated manner to improve the efficiency and safety of roadways and transit operations. ITS offers non-traditional solutions to transportation problems and provides an alternative to new infrastructure. An ITS Architecture provides a structured framework for deployment and integration. It helps to introduce and interconnect ITS services across a region. An ITS Architecture identifies "gaps" in systems and services and it assists in the development of cooperative agreements between / among agencies jointly deploying ITS.

MTC has recognized the significance and importance of sponsoring a regional ITS architecture and expects to use the Regional ITS Plan to leverage the current investment of ITS projects in the Bay Area and to ensure the orderly, cost-effective development and integration of projects in the future.

More specifically, the motivation for the overall Project includes:

- A recognition that a large number of ITS deployments have already occurred at local, corridor, and regional levels.
- The need for transportation system management to function at a larger corridor and regional scale to address growing problems; individual projects can only attack a portion of the problem.
- Expressed concerns over the lack of an explicit coordination framework across all projects.
- Potential technical incompatibilities preventing needed information exchange.
- Missed opportunities for enhanced functions or services within and across projects from lack of regional perspective.

Regional Goals

The regional ITS architecture and plan was guided by local and regional transportation policy goals. ITS goals, derived from adopted regional goals, provide the basis for assessment of ITS integration in the region and mapping out a program of future activities.

In the Bay Area, the Regional Transportation Plan (RTP), adopted in December 2001, has been guided by the six broad policy goals listed in the table below. Each of the six goals has multiple objectives, with the detailed objectives for Mobility and Safety.

Regional Transportation Plan - Policy Goals	
Mobility	Improve the ease and convenience of using the transportation system • Preserve the condition of the existing transportation system • Improve travel times in congested corridors by relieving bottlenecks and/or providing travel alternatives • Improve the reliability of the transportation system so that users can expect relatively consistent travel times from day-to-day for the same trip on the same mode • Increase coordination and convenience of transit service throughout the region • Provide travelers with good information when making trip decisions
Safety	Improve the safety of the transportation system for its users • Ensure key transportation facilities are capable of withstanding a major earthquake • Ensure MTC, Caltrans, and the Bay Area transportation operators can effectively coordinate their services following a major earthquake or other significant emergency that disrupts Bay Area transportation • Help ensure the safety of motorists using the Bay Area freeways • Help ensure the safety and security of transit system users • Assist local jurisdictions in their efforts to implement effective strategies to reduce serious injuries and loss of life for pedestrians and bicyclists
Equity	Promote equity for system users
Environment	Enhance sensitivity to the environment
Economic Vitality	Sustain the economic vitality of the region
Community Vitality	Promote vital and livable communities

Along with the RTP goals of Mobility and Safety, goal statements from the national ITS program, statewide plans, local ITS plans and studies, and discussions with stakeholders at meetings and workshops were reviewed. The result was a refined list, shown below, of regional ITS action goals to focus efforts for integration of ITS in the region and to provide the basis for future ITS planning.

RTP Policy Goals	Regional ITS Action Goals
Mobility	Mitigate Congestion • Improve travel times in congested corridors • Improve the reliability of the transportation system Enhance Transit Use • Increase coordination and convenience of transit Expand Travel Options • Provide travelers with good information
Safety	Improve Safety and Security • Ensure the safety of motorists • Ensure the safety and security of transit system users • Ensure effective transportation operations coordination during emergencies

Project Scope

Building upon the inventory and the assessment work from Phase 1, Phase 2 developed the Regional ITS Architecture, required by the FHWA Final Rule on National ITS Architecture conformity for federally funded ITS Systems. The initial step was to expand on the inventory produced during Phase 1 and itemize the ITS center elements in the Bay Area as existing or planned for implementation. Each of the ITS elements was mapped to an entity within the Physical Architecture of the National ITS Architecture.

In doing this, the stage was set for characterizing the current and planned level of interconnectivity between the ITS elements. For each ITS element, there was an expected set of interconnections with other ITS elements in the region based upon what the National ITS Architecture suggests as typical within its standardized common framework. Gaps and deviations became readily apparent and these were analyzed with respect to future planned projects.

The entire process was performed with the advice and consent of the key stakeholders in the region. Once the interconnections were determined, a second analysis went to a level deeper in detail and determined what type of information does or will flow through the connections between each pair of ITS elements. This served to organize the current state and future states of ITS using a standardized framework and nomenclature.

Beyond the connections, a high-level set of functional requirements were provided for each ITS element in the region. These were expanded into interagency operational concepts that described agency roles and responsibilities in providing ITS services to the region.

With these understandings of how ITS will work when services are provided by multiple agencies, a list of suggested agreements were identified so that each stakeholder agency could formally recognize their acceptance of the operational concept and their agreement to provide those functions and interfaces developed under the regional ITS architecture. The next step included working with the gaps and challenges in ITS service delivery. A list of ITS projects and action items were developed and confirmed

by the stakeholders to establish the basis of the ITS Plan. These projects were sequenced according to a scenario based on logical dependencies.

Beyond the documentation of the region's existing and planned ITS, there was also a need to describe how the architecture fits into the regional planning process. An approach showing how new projects are compared to the current architecture and how modifications and updates will be introduced was documented. An overall methodology for updating and maintaining the regional ITS architecture was recommended so that the stakeholders can maintain consistency with the regional ITS architecture.

With the completion of these steps, the Bay Area has complied with the FHWA Final Rule through a consensus process. More importantly, the Bay Area now has a common framework that offers a shared vision, an organizing vehicle, and a planning instrument that will serve the region for years to come.

How to Use this Report

This ITS Plan provides great detail on the specifics of the Bay Area regional ITS architecture development process, the resulting decisions, and the plan for the future. As an ITS project is deployed in the Bay Area, the project architecture must proceed based on consistency with the Bay Area Regional ITS Architecture. For example, if an agency wanted to build a Traffic Operations Center for their signal system incorporating other ITS devices, such as CCTV cameras and electronic signs, the process would proceed as follows (a similar process would be used if a transit system or a traveler information system or any other ITS project were of interest):

1. Consult the Regional ITS Architecture (this document) to see if the project had been previously captured under existing inventory in Appendix C or D or in the potential projects list from **Table 8**.
2. If the project has been included, then find the related:

    - Operational Concepts in **Table 6**
    - Functional Requirements in **Chapter 7**
    - System Interconnects and Information Flow Diagrams in **Appendix G**
    - Recommended and Appropriate Standards from **Appendix H**

3. Review these items and decide which interfaces and flows the current project must accommodate.
4. Contact the stakeholders referenced in the flow diagrams and coordinate the data to be exchanged and the standards to be used as a starting point.
5. Determine whether an agreement is required for the purpose of system integration and data exchange and other relevant terms. **Chapter 12** offers a list of potential agency agreements from which to start.
6. Review and submit all appropriate material as directed by Chapter 12.6 of the Caltrans Local Assistance Program (LAP) Guidelines.
7. Follow systems engineering process in project deployment. (If this process is unfamiliar, FHWA has support documentation and can provide training and guidance.)
8. Bring the project particulars before the Architecture Maintenance Team for assessment of consistency with the Regional Architecture, as noted in **Chapter 13**.

If the project has not been previously identified in the Regional Architecture, then a systems engineering process should be executed by the stakeholder to develop the items that modify the regional architecture, such as the services, operational concepts, functional requirements, system interconnects, agreements and information flows. Use the process detailed in **Section 13.2.4** of this report to inform the Architecture

Maintenance Team of any updates/changes. It is up to the Architecture Maintenance Team in the region to determine whether this information would need to be modified immediately in the regional architecture or whether it could be incorporated into the Regional Architecture during a routine maintenance cycle.

1.0 Introduction

This report represents the final product of the Regional Intelligent Transportation Systems (ITS) Plan project for the San Francisco Bay Area. The plan is being prepared for the Metropolitan Transportation Commission (MTC), based on input from a broad range of regional stakeholders.

MTC was created by the California legislature in 1970 to provide transportation planning for the nine-county San Francisco Bay Area. MTC functions as both the regional transportation planning agency (RTPA) and the region's metropolitan planning organization (MPO). Beyond its traditional role as the RTPA/MPO, MTC also coordinates and operates projects with the goal of increasing the efficient operation of the transportation network. MTC's involvement in projects related to Intelligent Transportation Systems (ITS) grew out of this goal.

ITS refers to electronic and communications systems that can be used for collecting, processing, disseminating, or acting on information in real time to improve the operation, safety, or convenience of the transportation system. This definition encompasses a broad range of systems and technologies and has created many new opportunities for transportation professionals to respond proactively to increasing demand for effective transportation services. Many of these new opportunities are predicated upon effective coordination between organizations, at both the institutional and technical level. To encourage this coordination, the U.S. Department of Transportation (USDOT) has developed the National ITS Architecture and related tools.

An "architecture" is a concept from the field of systems engineering that defines the framework within which a system can be built, the functionality of the pieces of the system, and the information that is exchanged between the components of the system. An architecture is functionally oriented and not technology specific. This feature allows architecture to remain effective over time and not become obsolete as technology evolves. Applying this definition to ITS, the National ITS Architecture defines the inter-related systems that work together to deliver transportation services and the interconnections and information exchanges between these systems.

The National ITS Architecture is a general framework for planning, defining, and integrating ITS and is available as a resource for any region. The National ITS Architecture offers many advantages as the basis for creating a regional ITS architecture. Primary among these advantages is a significant savings in time and expense because the National ITS Architecture represents a complete framework of ITS services, nationwide consensus of stakeholders, and offers a variety of tools to assist in creation of a regional architecture. In addition, by conforming to the National ITS Architecture, a region is then in compliance with the Transportation Equity Act for the 21st Century (TEA-21) and remains eligible for federal funding.

MTC has recognized the significance and importance of sponsoring a regional ITS architecture and proceeded with the Regional ITS Plan for the San Francisco Bay Area. MTC expects to use the Regional ITS Plan to leverage the current investment of ITS projects in the Bay Area and to ensure the orderly, cost-effective development and integration of projects in the future.

1.1 Project Background

The motivation for the Bay Area Regional ITS Planning project was:

- A recognition that a large number of ITS deployments have already occurred at local, corridor, and regional levels.
- The need for transportation system management to function at a larger corridor and regional scale to address growing problems; individual projects can only address a portion of the problem.
- Expressed concerns over the lack of an explicit coordination framework across all projects.
- Potential technical incompatibilities preventing needed information exchange.
- Missed opportunities for enhanced functions or services within and across projects from lack of regional perspective.

The overall project proceeded under two main phases. Phase 1 focused on the collection of ITS project inventory and an assessment of that inventory compared to regional transportation planning goals. The culmination of this activity was the "State of ITS in the Bay Area Report", which provided actionable information for discussion within MTC and with stakeholders in order to focus the Phase 2 activities.

Phase 2 of the project proceeded through a regional architecture development process as suggested by the FHWA and resulted in a Regional ITS Plan for implementing systems based on a regional architecture and for providing technical guidance on the existing and planned system connections.

1.2 Organization of This Document

Each of the written deliverables for the Bay Area Regional ITS Plan was introduced to the stakeholders as a Technical Memorandum. This Report is a compilation of those memos into one comprehensive document concerning the ITS Architecture development as well as other associated activities. After receiving stakeholder comments on each memo, a disposition of comments was released detailing the individual comments and how they were dealt with in modifying the memo under review.

Following is a summary listing of the sections and appendices that, in total, make up the complete documentation set for the Bay Area Regional ITS Plan.

- Executive Summary
- Section 1: Introduction
- Section 2: Bay Area ITS Focus
- Section 3: Regional Boundaries
- Section 4: ITS Inventory
- Section 5: ITS User Needs and Services
- Section 6: Operational Concepts
- Section 7: Functional Requirements
- Section 8: High Level ITS Architecture
- Section 9: Relevant Standards
- Section 10: Project Sequencing
- Section 11: Regional Perspectives
- Section 12: Agency Agreements
- Section 13: Maintenance Plan

- Appendix A: List of Acronyms
- Appendix B: List of Stakeholders
- Appendix C: Bay Area ITS Inventory (sorted by stakeholder agency)
- Appendix D: Bay Area ITS Inventory (sorted by architecture entity)
- Appendix E: Bay Area Market Package Descriptions
- Appendix F: Bay Area ITS Inventory and Market Packages
- Appendix G: Interconnects and Information Flows (offered as a separate document)
- Appendix H: Detailed Listing of NTCIP Standards for the Bay Area (offered as a separate document)
- Appendix I: National ITS Architecture Updates
- Appendix J: Turbo Architecture™ Updates

2.0 Bay Area ITS Focus

A main focus of the Bay Area Regional ITS Plan is to support and be guided by local and regional transportation policy (RTP) goals. ITS goals, derived from adopted RTP goals, provided the basis for ITS integration in the region and mapping out a program of future activities.

In the Bay Area, the Regional Transportation Plan (RTP), adopted in December 2001, has been guided by the six broad policy goals listed in Table 1. Each of the six goals has multiple objectives, with the detailed objectives for Mobility and Safety presented in Table 1.

Table 1: Regional Transportation Plan – Policy Goals

Regional Transportation Plan - Policy Goals	
Mobility	Improve the ease and convenience of using the transportation system • Preserve the condition of the existing transportation system • Improve travel times in congested corridors by relieving bottlenecks and/or providing travel alternatives • Improve the reliability of the transportation system so that users can expect relatively consistent travel times from day-to-day for the same trip on the same mode • Increase coordination and convenience of transit service throughout the region • Provide travelers with good information when making trip decisions
Safety	Improve the safety of the transportation system for its users • Ensure key transportation facilities are capable of withstanding a major earthquake • Ensure MTC, Caltrans, and the Bay Area transportation operators can effectively coordinate their services following a major earthquake or other significant emergency that disrupts Bay Area transportation • Help ensure the safety of motorists using the Bay Area freeways • Help ensure the safety and security of transit system users • Assist local jurisdictions in their efforts to implement effective strategies to reduce serious injuries and loss of life for pedestrians and bicyclists
Equity	Promote equity for system users

Regional Transportation Plan - Policy Goals	
Environment	Enhance sensitivity to the environment
Economic Vitality	Sustain the economic vitality of the region
Community Vitality	Promote vital and livable communities

Along with the RTP goals of Mobility and Safety, goal statements from the national ITS program, statewide plans, local ITS plans and studies, and discussions with stakeholders at meetings and workshops were reviewed. The result was a refined list, shown in Table 2, of regional ITS action goals to focus efforts for integration of ITS in the region and to provide the basis for future ITS planning.

Table 2: Regional ITS Goals

RTP Policy Goals	Regional ITS Action Goals
Mobility	Mitigate Congestion • Improve travel times in congested corridors • Improve the reliability of the transportation system Enhance Transit Use • Increase coordination and convenience of transit Expand Travel Options • Provide travelers with good information
Safety	Improve Safety and Security • Ensure the safety of motorists • Ensure the safety and security of transit system users • Ensure effective transportation operations coordination during emergencies

The deployment of ITS supports the RTP goals by providing new and innovative solutions to regional transportation problems, especially in the areas of mobility and safety. Effective consideration of these goals has potentially positive implications for the remaining RTP goals as well.

3.0 Regional Boundaries

Regional ITS architecture efforts begin with a focus on the boundaries of the study. The boundaries considered by the Bay Area region concerned locale, timing, and stakeholders.

3.1 Regional Description

The geographical area covered by this Plan includes the nine San Francisco Bay Area Counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. Additionally, adjacent jurisdictions, were also considered to the extent that there are interactions with Bay Area transportation systems. A base map of the nine-county San Francisco Bay Area is depicted in Figure 1.

3.2 Timeframe

According to FHWA guidelines, the regional ITS architecture should look far enough into the future so that the efficient integration of ITS services can be guided over time. The Bay Area ITS architecture planning horizon was chosen to be 10 years, which is long enough to include most of the system integration opportunities as anticipated by the regional stakeholders.

3.3 Stakeholder Description

The success of the regional ITS architecture depends on participation by a diverse set of stakeholders. In the context of this project, stakeholders are defined as a core set of public agencies with transportation-related oversight, responsibility, and/or duties in the San Francisco Bay Area. When it comes to transportation issues in the Bay Area, there are numerous other entities, agencies, and concerned, affected groups that may have an interest in a project such as this. But, using Federal Highway Administration (FHWA) guidelines* , it is often best to start with a core stakeholder group and add participants over time.

Within the Bay Area region, there are numerous transportation system stakeholders, including cities, counties, the Metropolitan Transportation Commission (MTC), the California Department of Transportation (Caltrans), the California Highway Patrol (CHP), congestion management agencies, transit agencies, and other special purpose agencies. A list of stakeholder agencies for the Bay Area Regional ITS Architecture is provided in Appendix B.

In addition to the identification of stakeholders, the guidelines for applying the National ITS Architecture to a regional ITS architecture process recommend the identification of the regional architecture champion. The champion is one or more key persons leading the regional ITS architecture development, is also a stakeholder, and is proactive in the field of ITS. The champion must understand the subject at hand, have knowledge of local ITS systems and projects, and have a vision for interconnectivity, partnership, and regional integration. The champion for the San Francisco Bay Area Regional ITS Architecture is the Metropolitan Transportation Commission.

* "National ITS Architecture Guidance, Developing, Using, and Maintaining an ITS Architecture for Your Region", dated October 12, 2001

Figure 1: San Francisco Bay Area Map of Counties

The stakeholders participated in numerous project meetings and workshops to accomplish the activities necessary to complete the Regional ITS Plan. The dates of the meetings were:

Phase 1:
- April 17, 2001
- August 20-21, 2001
- August 28, 2001
- October 17, 2001
- January 8, 2002
- February 20, 2002
- April 10, 2002
- May 14, 2002
- November 21, 2002

Phase 2:
- June 12, 2003
- September 17, 2003
- December 10, 2003
- February 18, 2004
- April 15, 2004
- May 21, 2004

4.0 ITS Inventory

As defined in the FHWA Rule, and for purposes of this Plan, an ITS inventory is a list of ITS elements and the elements that interface with them. An element is then defined as the name used by stakeholders to describe an ITS system or piece of a system. Thus, the ITS Inventory is a record of the Bay Area Intelligent Transportation Systems and their related elements, both existing and planned. In association with the ITS inventory, it is important to identify the ITS owners and/or operators, the presence of operation centers, and the connections (communication links and data flows) internally between various system elements and externally to other systems. Identifying technological aspects of the ITS inventory is not necessary; rather, assessing the function and capabilities of the various systems is vital. Furthermore, the total number of various ITS elements (such as signals, CCTV cameras, buses with automatic vehicle locators, etc.) that exist, and the location of all these elements, is not critical with respect to developing a Regional ITS Architecture.

The participation of local stakeholders was critical to the development of the Bay Area ITS Architecture and the accompanying documentation. Their input was specifically requested at many different stages of the project, including the development of the ITS inventory.

4.1 Project vs. Systems Inventory

In Phase 1, an ITS projects inventory was undertaken through an outreach process. To populate and validate the project inventory database, the consultant team:

- Conducted six Project Stakeholder Meetings to solicit project inventory input.
- Facilitated a Stakeholder Workshop to review inventory and discuss assessment criteria.
- Conducted over 40 interviews of core stakeholders in the Bay Area through face-to-face meetings, phone contacts, or at local meetings.
- Reviewed a large number of ITS plans, studies, local ITS committee records, and strategies developed by state, regional, and local agencies.

These outreach efforts and the collection of the resultant ITS project inventory occurred from October 2001 through June 2002. The project team initially utilized a software and web access tool called

ProjectSolve to provide regional stakeholder access to the ITS Project Inventory Database, the Data Repository, and the Resources and Issues Database.

To proceed to architecture development in Phase 2, the "projects" inventory needed to be converted to a "systems" inventory. A project inventory focuses on a specific service or portions of services that are funded and/or implemented separately from anything else that is going on in the region. Projects are often focused on putting some "thing" in place (such as cameras, a Traffic Management Center, an ITS Plan, fiber communications, electronic signage, etc.).

A system inventory is an inventory of software, hardware, and functions that take place in a region to accomplish electronic data exchange in support of ITS services. Systems are not "brick and mortar" or "facility oriented"; systems are a collection of functions. There may be one system used throughout a region and interconnected to many stakeholders (such as TransLink, or 511) or it may be a tool used for communication of information between specific and limited agencies. The systems inventory does not include details on systems internal to an agency that are not available for external data exchange.

4.2 Using Turbo Architecture ™

A systems inventory is also the input basis for entering data into Turbo Architecture™ (Turbo), a tool used to facilitate system architecture interconnections and data flows. Turbo is an interactive software application that assists ITS planners and system integrators, both in the public and private sectors, in the development of regional and project architectures using the National ITS Architecture as a starting point. Turbo Version 2.0, being used for this project, supports development of regional and system architectures that take advantage of features in Version 4.0 of the National ITS Architecture.

The inputs to Turbo are based on the systems inventory. Information was entered into Turbo using a survey form used by the consultant team to translate the project inventory to the systems inventory. The survey form guided the consultant team through a series of questions and options about each system that resulted in the creation of the systems inventory. The outputs of Turbo are saved in Microsoft Access-compatible data files.

The results of the conversion are presented in Appendix C, which contains the Bay Area ITS Inventory, sorted by stakeholder agency and including the associated element(s) for each system. (An element is a system or a piece of a system that comprise the basic building blocks of the regional ITS architecture.) Appendix D offers the same information sorted by architecture entity. The on-line version of this inventory can be accessed at: http://www.iteris.com/mtcits/. (Note that the project website will move to the MTC public website in the future – http://www.mtc.ca.gov/.)

5.0 ITS Users Needs and Services

ITS inventory for the Bay Area consisted of existing and planned (near term) systems owned and/or operated by Bay Area ITS stakeholders. In this section, the ITS services provided by these systems to address regional needs are identified, along with a discussion first on National ITS Architecture terminology.

5.1 National ITS Architecture Terminology

The National ITS Architecture contains many different concepts and is rich in industry terms and acronyms that depict integrated systems. One of the strengths of National ITS Architecture is the fact that it introduces a consistent language that can be shared with both planners and operators nationally, to assure that everyone is universally "on the same page" with systems implementation, integration, and operation. But if consistent terms and acronyms are strengths, then there is an equal challenge in that this language is often new to everyone. Like any new language, the language or dialect of "National Architecture-ease" is often awkward to use and understand.

Subsystems: Figure 2 is a generic, high-level depiction of ITS according to the National ITS Architecture. This illustration depicts ITS by four types of subsystems: Travelers, Centers, Vehicles and Roadside. The National ITS Architecture subsystems organize functions that occur within ITS deployments. For example, in Figure 2, the Caltrans District 4 Transportation Management Center (TMC) would be identified with the Center Subsystem in the National ITS Architecture known as "Traffic Management", because this is the subsystem where these functions take place. The cameras, signals, and other field equipment that gather information for the Caltrans District 4 TMC are identified with the Roadside Subsystem called “Roadway”. Also, in Figure 2, the oblong bubbles between the various types of subsystems represent the communications media that is typically used to connect the various subsystems.

Market Packages: Market Packages are another concept taken from the National ITS Architecture. Market Packages, comprised of one or more subsystems, provide accessible, deployment-oriented, integrated services from the framework of the National ITS Architecture that respond directly to regionally identified needs. Market Packages are the underlying deployment mechanism for implementing the various subsystems found in the National ITS Architecture high-level diagram.

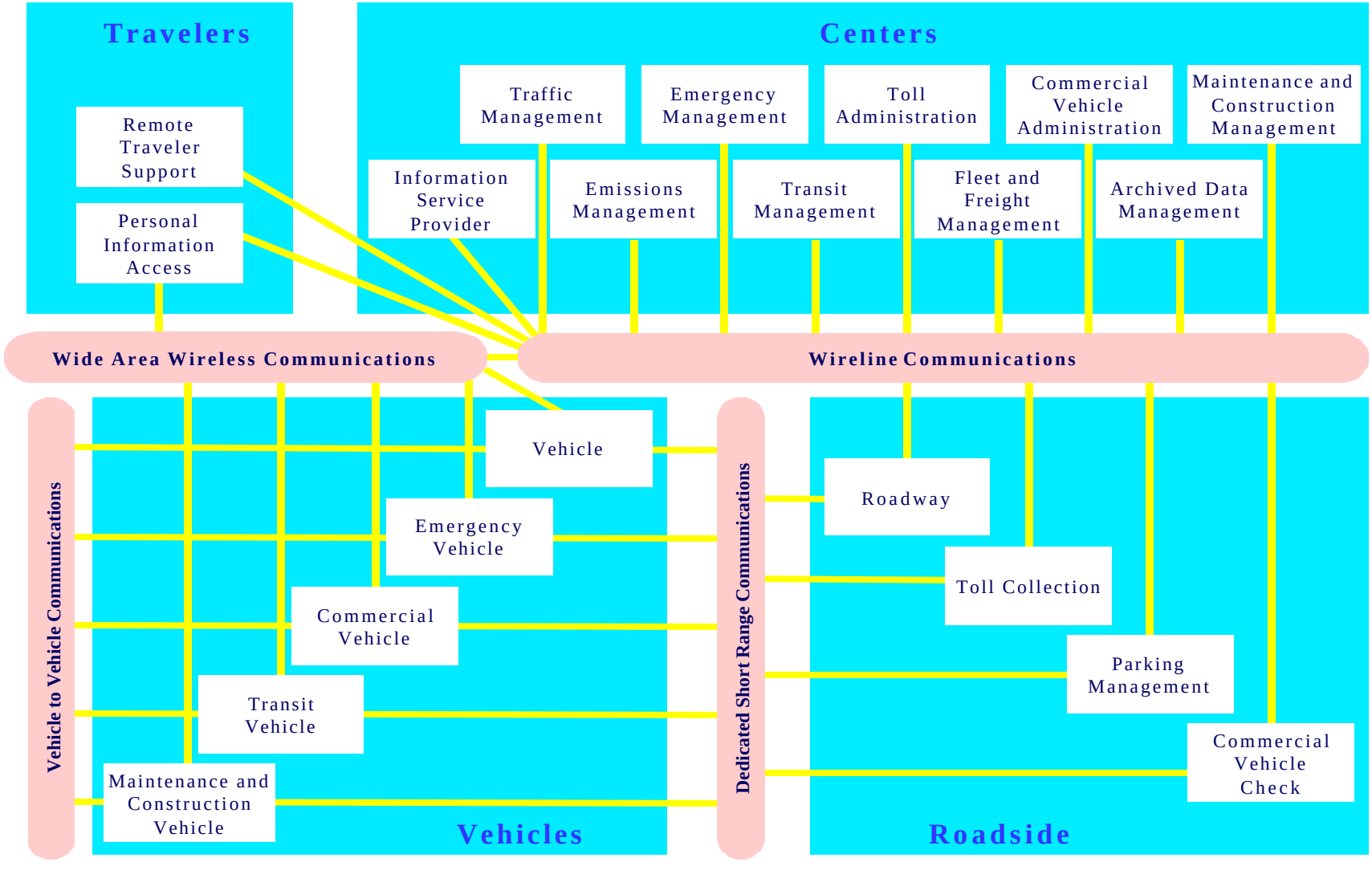
Once a region has identified specific ITS service needs, or prioritized ITS services, Market Packages that correlate most directly to those needs and priorities can be pulled out of the National ITS Architecture to serve as a beginning point of discussion for project deployment. Market Packages are then tailored to fit, separately or in combination, real world local transportation problems and needs identified during the ITS planning process.

Every ITS service selected for the region is associated with one or more regional stakeholders that supports or will be supporting that service. This association between ITS services and organizations serves as a starting point for operational concepts.

Terminators: Terminators are on the outside of what a region defines as transportation, but are frequently used by transportation to accomplish a mission or perform specific functions. An example of a terminator is a banking institution that may be utilized during the purchase of fare cards for transit. The banking institution subscribes to their own industry standards, but they are critical to fare card payment, toll collection, and other services provided in a region.

Information Flows: Information flows are defined as the information and data exchange between and among various stakeholder systems that have been mapped to subsystems and/or terminators. Information Flows allow for a coordinated overall system operation by following pre-defined interfaces between subsystems, which may be deployed by different procuring and operating sectors.

Figure 2: National ITS Architecture High-Level Diagram



In Version 4.0 of the National ITS Architecture, there are 75 Market Packages, in eight groupings. Table 3 contains a summary listing of all current National ITS Architecture Market Packages, by group. Each of the Bay Area Market Packages is briefly described in Appendix E. To further review the National ITS Architecture Market Package diagrams and descriptions, please refer to http://itsarch.iteris.com/itsarch/.

Table 3: Summary Listing of National ITS Architecture Market Packages

ARCHIVED DATA MANAGEMENT	
Archived Data (AD)	
AD1	ITS Data Mart
AD2	ITS Data Warehouse
AD3	ITS Virtual Data Warehouse
PUBLIC TRANSPORTATION	
Advanced Public Transportation Systems (APTS)	
APTS1	Transit Vehicle Tracking
APTS2	Transit Fixed-Route Operations
APTS3	Demand Response Transit Operations
APTS4	Transit Passenger and Fare Management
APTS5	Transit Security
APTS6	Transit Maintenance
APTS7	Multi-modal Coordination
APTS8	Transit Traveler Information
TRAVELER INFORMATION	
Advanced Traveler Information Systems (ATIS)	
ATIS1	Broadcast Traveler Information
ATIS2	Interactive Traveler Information
ATIS3	Autonomous Route Guidance
ATIS4	Dynamic Route Guidance
ATIS5	ISP Based Route Guidance
ATIS6	Integrated Transportation Management/Route Guidance
ATIS7	Yellow Pages and Reservation
ATIS8	Dynamic Ridesharing
ATIS9	In Vehicle Signing
TRAFFIC MANAGEMENT	
Advanced Transportation Management Systems (ATMS)	
ATMS01	Network Surveillance
ATMS02	Probe Surveillance
ATMS03	Surface Street Control
ATMS04	Freeway Control
ATMS05	HOV Lane Management
ATMS06	Traffic Information Dissemination
ATMS07	Regional Traffic Control
ATMS08	Incident Management System
ATMS09	Traffic Forecast and Demand Management
ATMS10	Electronic Toll Collection
ATMS11	Emissions Monitoring and Management
ATMS12	Virtual TMC and Smart Probe Data
ATMS13	Standard Railroad Grade Crossing
ATMS14	Advanced Railroad Grade Crossing
ATMS15	Railroad Operations Coordination
ATMS16	Parking Facility Management
ATMS17	Regional Parking Management
ATMS18	Reversible Lane Management
ATMS19	Speed Monitoring
ATMS20	Drawbridge Management
VEHICLE SAFETY	
Advanced Vehicle Safety Systems (AVSS)	
AVSS01	Vehicle Safety Monitoring
AVSS02	Driver Safety Monitoring
AVSS03	Longitudinal Safety Warning
AVSS04	Lateral Safety Warning
AVSS05	Intersection Safety Warning
AVSS06	Pre-Crash Restraint Deployment
AVSS07	Driver Visibility Improvement
AVSS08	Advanced Vehicle Longitudinal Control
AVSS09	Advanced Vehicle Lateral Control
AVSS10	Intersection Collision Avoidance
AVSS11	Automated Highway System
COMMERCIAL VEHICLE OPERATIONS	
Commercial Vehicle Operations (CVO)	
CVO01	Fleet Administration
CVO02	Freight Administration
CVO03	Electronic Clearance
CVO04	CV Administrative Processes
CVO05	International Border Electronic Clearance
CVO06	Weigh-In-Motion
CVO07	Roadside CVO Safety
CVO08	On-board CVO Safety
CVO09	CVO Fleet Maintenance
CVO10	HAZMAT Management
EMERGENCY MANAGEMENT	
Emergency Management (EM)	
EM1	Emergency Response
EM2	Emergency Routing
EM3	Mayday Support
EM4	Roadway Service Patrols
MAINTENANCE & CONSTRUCTION OPERATIONS	
Maintenance & Construction Operations (MCO)	
MC01	Maintenance and Construction Vehicle Tracking
MC02	Maintenance and Construction Vehicle Maintenance
MC03	Road Weather Data Collection
MC04	Weather Information Processing and Distribution
MC05	Roadway Automated Treatment
MC06	Winter Maintenance
MC07	Roadway Maintenance and Construction
MC08	Work Zone Management
MC09	Work Zone Safety Monitoring
MC10	Maintenance and Construction Activity Coordination

From the National ITS Architecture (v4.0)

5.2 Bay Area Market Packages

Table 4 is a summary of Market Packages for the Bay Area, as derived based on systems inventory and regional need. The table shows the entire listing of Market Packages from the National ITS Architecture and their respective status in the region. The Market Packages are categorized as: Existing, Planned, or Not Planned.

For the purposes of this Plan, "Existing" is defined as currently in place and operating. "Existing" can also mean currently under construction/development, or construction/development is imminent – e.g. a project to implement the Market Package is programmed and budgeted and is likely being advertised or is about to be advertised for implementation. The "Planned" category is defined as a proposed project that may or not be programmed, implementation is not imminent, nor expected in the first year or two of the ITS Architecture planning horizon. It may be programmed for implementation in an out year of the current Transportation Improvement Program (TIP). It may also be as simple as a stakeholder agency stating that they would like to implement a certain ITS function and that they are moving toward that goal internally, by performing cost/benefit analyses, conducting preliminary technical or marketing studies, working on medium to long range budget proposals for the project, staff educating management and elected officials of the benefits of the implementation (or vice versa), or establishing contacts with neighboring agencies to promote the implementation.

Market Packages designated "Not Planned" are defined as there being no apparent evidence that a given Market Package functionality will be implemented by any of the project stakeholders in the ITS Architecture planning horizon or that there was no stakeholder champion willing to take the lead in its deployment.

In addition to Market Package status, Table 4 also includes the prioritization of the Market Packages. Several sources were used to determine the priority of Market Packages for the Bay Area region. The primary source was the first deliverable of Phase 2 of this project, titled "Phase 2 Focus Memorandum", which assigned a priority to several key issues identified in Phase 1 of this project as well as several other new issues that have become prominent at the intermission period between Phases 1 and 2.

Other sources of information for prioritization of Market Packages came in the form of stakeholder input on projects and systems. In many cases, priority was garnered during the project and systems inventory processes. In some cases, primarily in the case of the Market Packages designated low priority, the priorities were inferred by a lack of input from the stakeholders. Wherever a Market Package was placed into the Not Planned category, it is assigned a priority of N/A for Not Applicable. Please note that this table does not represent the relative level of regional deployment of a specific Market Package. If even a single existence of a deployment occurred in the region, the Market Package was marked as "Existing".

Appendix E contains the complete set of Bay Area Market Package descriptions from Version 4.0 of the National ITS Architecture. Appendix F presents the Bay Area ITS Inventory with associated Market Packages noted.

Table 4: Refined Market Package Analysis

Market Packages		Existing	Planned	Not Planned	Priority: H (High) M (Medium) L (Low) N/A (Not Applicable)
ARCHIVED DATA MANAGEMENT *Archived Data (AD)*					
AD1	ITS Data Mart	●			**H**
AD2	ITS Data Warehouse		●		**L**
AD3	ITS Virtual Data Warehouse			●	**N/A**
PUBLIC TRANSPORTATION *Advanced Public Transportation Systems (APTS)*					
APTS1	Transit Vehicle Tracking	●			**H**
APTS2	Transit Fixed-Route Operations	●			**H**
APTS3	Demand Response Transit Operations	●			**M**
APTS4	Transit Passenger and Fare Management	●			**H**
APTS5	Transit Security	●			**H**
APTS6	Transit Maintenance	●			**M**
APTS7	Multi-modal Coordination		●		**H**
APTS8	Transit Traveler Information	●			**H**
TRAVELER INFORMATION *Advanced Traveler Information Systems (ATIS)*					
ATIS1	Broadcast Traveler Information	●			**M**
ATIS2	Interactive Traveler Information	●			**H**
ATIS3	Autonomous Route Guidance			●	**N/A**
ATIS4	Dynamic Route Guidance			●	**N/A**
ATIS5	ISP Based Route Guidance			●	**N/A**
ATIS6	Integrated Transportation Management/Route Guidance			●	**N/A**
ATIS7	Yellow Pages and Reservation			●	**N/A**
ATIS8	Dynamic Ridesharing			●	**N/A**
ATIS9	In Vehicle Signing			●	**N/A**
TRAFFIC MANAGEMENT *Advanced Transportation Management Systems (ATMS)*					
ATMS01	Network Surveillance	●			**H**
ATMS02	Probe Surveillance	●			**M**
ATMS03	Surface Street Control	●			**H**
ATMS04	Freeway Control	●			**H**
ATMS05	HOV Lane Management	●			**H**
ATMS06	Traffic Information Dissemination	●			**H**
ATMS07	Regional Traffic Control		●		**M**
ATMS08	Incident Management System	●			**H**

Market Packages		Existing	Planned	Not Planned	Priority: H (High) M (Medium) L (Low) N/A (Not Applicable)
ATMS09	Traffic Forecast and Demand Management			●	**N/A**
ATMS10	Electronic Toll Collection	●			**H**
ATMS11	Emissions Monitoring and Management			●	**N/A**
ATMS12	Virtual TMC and Smart Probe Data			●	**N/A**
ATMS13	Standard Railroad Grade Crossing	●			**L**
ATMS14	Advanced Railroad Grade Crossing		●		**L**
ATMS15	Railroad Operations Coordination			●	**N/A**
ATMS16	Parking Facility Management		●		**M**
ATMS17	Regional Parking Management			●	**N/A**
ATMS18	Reversible Lane Management			●	**N/A**
ATMS19	Speed Monitoring			●	**N/A**
ATMS20	Drawbridge Management			●	**N/A**
VEHICLE SAFETY *Advanced Vehicle Safety Systems (AVSS)*					
AVSS01	Vehicle Safety Monitoring			●	**N/A**
AVSS02	Driver Safety Monitoring			●	**N/A**
AVSS03	Longitudinal Safety Warning			●	**N/A**
AVSS04	Lateral Safety Warning			●	**N/A**
AVSS05	Intersection Safety Warning			●	**N/A**
AVSS06	Pre-Crash Restraint Deployment			●	**N/A**
AVSS07	Driver Visibility Improvement			●	**N/A**
AVSS08	Advanced Vehicle Longitudinal Control			●	**N/A**
AVSS09	Advanced Vehicle Lateral Control			●	**N/A**
AVSS10	Intersection Collision Avoidance			●	**N/A**
AVSS11	Automated Highway System			●	**N/A**
COMMERCIAL VEHICLE OPERATIONS *Commercial Vehicle Operations (CVO)*					
CVO01	Fleet Administration			●	**N/A**
CVO02	Freight Administration			●	**N/A**
CVO03	Electronic Clearance		●		**L**
CVO04	CV Administrative Processes		●		**L**
CVO05	International Border Electronic Clearance			●	**N/A**

Market Packages		Existing	Planned	Not Planned	Priority: H (High) M (Medium) L (Low) N/A (Not Applicable)
CVO06	Weigh-In-Motion	●			**M**
CVO07	Roadside CVO Safety		●		**M**
CVO08	On-board CVO Safety			●	**N/A**
CVO09	CVO Fleet Maintenance			●	**N/A**
CVO10	HAZMAT Management		●		**L**
EMERGENCY MANAGEMENT *Emergency Management (EM)*					
EM1	Emergency Response	●			**H**
EM2	Emergency Routing		●		**M**
EM3	Mayday Support			●	**N/A**
EM4	Roadway Service Patrols	●			**H**
MAINTENANCE & CONSTRUCTION OPERATIONS *Maintenance & Construction Operations (MCO)*					
MC01	Maintenance and Construction Vehicle Tracking	●			**L**
MC02	Maintenance and Construction Vehicle Maintenance			●	**N/A**
MC03	Road Weather Data Collection			●	**N/A**
MC04	Weather Information Processing and Distribution		●		**L**
MC05	Roadway Automated Treatment			●	**N/A**
MC06	Winter Maintenance			●	**N/A**
MC07	Roadway Maintenance and Construction			●	**N/A**
MC08	Work Zone Management			●	**N/A**
MC09	Work Zone Safety Monitoring			●	**N/A**
MC10	Maintenance and Construction Activity Coordination		●		**L**

6.0 Operational Concepts

The intent of this section is to present a Bay Area operational concept that identifies stakeholder roles and responsibilities, thereby illuminating critical relationships, identifying key functions performed by stakeholders, and describing the information that is produced and shared.

6.1 Operational Concept Defined

In ITS architecture development, there are two terms that are often used: Operational Concept and Concept of Operations (COP). A COP defines in detail the specifics of how a system or project operates in different scenarios by combining user and system functions in a narrative fashion. An operational concept is based on principles of systems engineering and is a stakeholder-oriented document that

describes system operational characteristics from the stakeholder's viewpoint. The use of these types of documents has proven valuable as a means to successfully communicate the information that stakeholders need and expect from system to system interconnect.

Applied to transportation management and operations, an operational concept is therefore a strategy for achieving a shared set of expectations of operations and delivery of services to be provided by a regional transportation system. These expectations are typically performed by system operators and system managers in response to local/regional needs.

At an implementation level, ultimate build-out of the regional transportation system involves personal relationships, communications capabilities (verbal and non verbal/electronic), procedural protocols, information gathering and sharing arrangements, interagency mutual aid agreements both written and unwritten, and dissemination systems (the hardware and software of the various systems). An operational concept documents both existing and future stakeholder roles and responsibilities as identified by those stakeholders that are used to manage transportation facilities and services in the region. Future reports under this project will provide details on the functional requirements of the transportation systems and the agreements required to support these requirements.

The benefits that result from the use of an operational concept include the following:

- Improved accountability and control for the various activities and functions that are undertaken in transportation management and operations
- Provision of faster, more coordinated responses to incidents, emergencies, and natural disasters such as earthquakes
- Avoidance of duplicative and/or conflicting efforts by various transportation and public safety jurisdictions, agencies, departments, and other entities
- Clarification of expectations and intent so that all stakeholders are aware of the consequences of their actions on other stakeholders
- Clarification of roles/responsibilities of all stakeholders so activities do not "fall through the cracks"
- Sharing of data and information across agency and jurisdictional boundaries to allow for seamless operations

6.2 Roles and Responsibilities

Operational concepts focus on a definition of each stakeholder's role in delivering transportation systems and services. The operational concept process develops and documents stakeholders' current and future roles and responsibilities in the implementation and operation of ITS and non-ITS activities based on a common regional architecture. Having clear operational roles and responsibilities allows the identification of each stakeholder's ITS role. The process also assists in identifying gaps and duplication of efforts for clarification.

In developing the list of stakeholders to include under operational concepts, the intent was to encompass unique stakeholders individually and group certain stakeholders together who had similar roles and responsibilities. In addition, although Commercial Vehicle Operation market packages were identified, further analysis was deferred as to such a time that the Statewide ITS Architecture and the Bay Area Goods Movement efforts are complete. The impacts of those activities on the Bay Area ITS Regional Plan will be addressed during a maintenance phase.

To ensure that all market packages applicable to the Bay Area are associated with one or more stakeholder, Table 5 provides an overview of this mapping. Operational concepts are presented in Table 6 detailing the roles and responsibilities of individual or groupings of Bay Area stakeholders.

Table 5: Mapping Stakeholders To Market Packages

Stakeholder	Archived Data Management	Emergency Management	Maintenance and Construction Management	Public Transportation	Traffic Management	Traveler Information
California Highway Patrol		●			●	●
Caltrans District 4	●	●	●		●	●
Metropolitan Transportation Commission		●		●	●	●
Smart Corridor Partnerships					●	●
Sub-Regional and Local Cities/County - Police, Fire, Sheriff		●				
Sub-Regional and Local Cities/County - Traffic Operators		●			●	●
Toll Operators					●	
Transit Operators				●		●

Table 6: Bay Area Operational Concepts

Stakeholder	Roles / Responsibility
California Highway Patrol (CHP)	Emergency Management • Receive cellular 911 public safety calls and forward to appropriate dispatch center • Dispatch CHP patrol vehicles • Interface with other transportation agencies to support coordinated emergency/incident response involving multiple agencies. • Use real-time traffic information received from other transportation agencies to aid the dispatcher in selecting the patrol vehicle(s) and routes that will provide a timely response. • Create, store, and utilize emergency/incident response plans to facilitate coordinated response. • Maintain centralized emergency management system. • Perform other "non-transportation related" public safety duties. • Be first responder to emergencies/incidents (typically). • Provide the "incident manager" at the emergency/incident scene. • Provide security for public facilities owned by the state. • Jointly participate in the call box (SAFE) program. Traffic Management • Track and manage FSP tow trucks and CHP vehicle fleets. • Monitor traffic on designated arterials and freeways. • Operate and monitor electronic credentialing and safety screening programs (i.e. weigh in motion facilities, etc.). • Jointly operate the regional Transportation Management Center (TMC). • Maintain and operate the backup TMC, as necessary. • Jointly participate in the Freeway Service Patrol (FSP) program. • Provide real-time FasTrak electronic toll collection/HOT lane violation enforcement. Traveler Information • Provide traffic, emergency, and incident information to the public both at the scene of the incident and from control centers. • Provide traffic, emergency, and incident data to regional TravInfo/511 center. • Update information to Information Service Providers (ISPs) and media outlets (web sites, TV, etc.). • Request alerts on appropriate disseminations devices. • Report incident related freeway road closures to other transportation agencies.

Stakeholder	Roles / Responsibility
Caltrans District 4	Archived Data Management • Collect and provide transportation data to others (i.e. PeMS) for archive purposes. Emergency Management • Provide resources when requested by emergency/incident management responders. • Implement and coordinate traffic control response to emergencies/incidents. • Maintain centralized emergency management system. • Jointly participate in the call box (SAFE) program. • Receive public safety calls forwarded from the Call Answering Center (CAC) (which received the call from bridge and tunnel call boxes) and respond as appropriate. Maintenance and Construction Management • Determine maintenance vehicle locations. • Send maintenance vehicle location information to TMC. • Maintain vehicle status for deployment. • Send status information to TMC. • Maintain vehicle location systems for maintenance vehicles. Traffic Management • Jointly operate the regional TMC. • Manage and monitor traffic on freeway on-ramps and Caltrans controlled highways. • Manage and monitor traffic on freeways including HOV and HOT lane management. • Share traffic information with other transportation agencies. • Implement enhanced traffic management strategies. • Jointly participate in the Freeway Service Patrol (FSP) program. • Maintain field equipment. • Report and coordinate road closures to all relevant transportation agencies in the event of a major emergency/incident. • Maintain centralized signal system. • Receive signal priority requests from transit operators (where applicable). • Provide transit signal priority response (where applicable). • Receive preemption requests from emergency vehicle operators (where applicable).

Stakeholder	Roles / Responsibility
Caltrans District 4 (continued)	• Provide preemption response (where applicable). • Share freeway device control with other transportation agencies (where appropriate). • Operate and maintain toll lane equipment. • Monitor weather conditions along roadways. <u>Traveler Information</u> • Provide traffic, emergency, and incident information to drivers and other transportation agencies. • Provide road weather conditions to other transportation agencies. • Install appropriate detection and dissemination devices along the freeways
Metropolitan Transportation Commission (MTC)	<u>Emergency Management</u> • Maintain and manage a regional call box system. (MTC SAFE) • Operate a private call box Call Answering Center (CAC). (MTC SAFE) • Cooperate with other state SAFE programs that could use the CAC for their programs. (MTC SAFE) • Coordinate regional emergency response. <u>Public Transportation</u> • Manage implementation of the regional fare payment system, TransLink. <u>Traffic Management</u> • Jointly operate a regional TMC. • Manage regional signal timing coordination program. • Develop, operate, and maintain center-to-center communications program. • Manage the Freeway Service Patrol (FSP) program in cooperation with CHP and Caltrans D4. (MTC SAFE) • Operate and maintain an FSP data exchange system with CHP and Caltrans D4 for dispatching, fleet management (AVL), and data reporting. (MTC SAFE) • Integrate FSP telecommunication systems with CHP and Caltrans traffic management efforts. (MTC SAFE) <u>Traveler Information</u> • Operate and maintain regional transit trip planning program. • Operate and maintain regional traveler information/511 system. • Install and maintain field devices on the freeways that support 511 needs.

Stakeholder	Roles / Responsibility
Smart Corridor Partnerships	Traffic Management • Provide strategic management of the facilities in the corridor. • Maintain centralized signal system. • Develop corridor wide traffic control response to emergencies/incidents. • Share control of field equipment with other transportation agencies. Traveler Information • Provide traffic, emergency, and incident information to the public and other transportation agencies. • Receive traffic information from other transportation agencies outside the corridor and distribute it within the corridor.
Sub-regional and Local Cities/County - Police, Fire, Sheriff	Emergency Management • Receive landline public safety calls and forward to appropriate dispatch center. • Dispatch local police, fire, and ambulance vehicles. • Interface with other transportation agencies to support coordinated emergency response involving multiple agencies. • Create, store, and utilize emergency/incident response plans to facilitate coordinated response. • Track and manage emergency vehicle fleets. • Use traffic information received from other transportation agencies to aid the dispatcher in selecting the emergency vehicle(s) and routes that will provide a timely response. • Monitor traffic on designated arterials. • Provide traffic and incident information to drivers and other transportation agencies. • Maintain centralized emergency management system. • Share appropriate detection and dissemination devices along major arterials with other transportation agencies. • Provide security for public facilities owned by the local agency. • Report road closures to all relevant transportation agencies in the event of a major emergency/incident.

Stakeholder	Roles / Responsibility
Sub-regional and Local Cities/County - Traffic Operators	<u>Emergency Management</u> • Provide resources when requested by other transportation agencies. <u>Emergency Management</u> • Provide resources when requested by other transportation agencies. <u>Traffic Management</u> • Monitor and manage traffic on arterials. • Maintain centralized signal system. • Implement enhanced traffic management strategies. • Install appropriate detection and dissemination devices along major corridors. • Implement and coordinate traffic control response to emergencies/incidents. • Share control of field equipment with other transportation agencies. • Maintain field equipment. • Report and coordinate road closures to all relevant transportation agencies in the event of a major emergency/incident. • Receive signal priority requests from transit operators (where applicable). • Provide transit signal priority response (where applicable). • Provide preemption for emergency vehicles (where appropriate). • Provide preemption response (where applicable). • Coordinate traffic signal response at highway-rail intersections. • Initiate adverse weather event signal timing and coordination, where feasible. • Assist in coordinating traffic signals across boundaries. • Monitor weather conditions along roadways. • Support use of TransLink for non-transit purposes (such as for parking). <u>Traveler Information</u> • Provide traffic, emergency, and incident information to the public and other transportation agencies. • Provide road weather conditions to other transportation agencies.
Toll Operators	<u>Traffic Management</u> • Maintain and operate field and office toll collection facilities/equipment. • Assign appropriate toll credit to appropriate agencies. • Manage toll collection process. • Support CHP violation enforcement. • Identify and process toll violations.

Stakeholder	Roles / Responsibility
Transit Operators	<u>Public Transportation</u> • Coordinate schedules with other transportation agencies. • Track and manage fleets. • Receive fleet location and occupancy information from vehicle. • Send fleet status and location information to operations center. • Maintain passenger counts. • Send passenger counts to operations center. • Issue requests for traffic signal priority (where applicable). • Maintain operations system. • Support, implement, and operate the regional fare payment system, TransLink. • Determine maintenance vehicle locations for respective agency. • Maintain vehicle status for deployment. • Provide security for public facilities owned by the transit agency. <u>Traveler Information</u> • Provide transit information to the public and other transportation agencies.

7.0 Functional Requirements

In previous sections, an ITS Inventory for the Bay Area was presented that showed existing and planned (near term) systems owned and/or operated by Bay Area ITS Stakeholders. Next, the list of services from the National ITS Architecture market packages was compared to the Bay Area ITS inventory to determine which services are currently being met with existing ITS deployments, will be met in the near future with planned ITS deployments, or are not being addressed in the Bay Area. Operational concepts then provided an overview of the roles and responsibilities of the Bay Area Stakeholders that provide the basis for fulfillment of the ultimate architecture.

The next step in the regional ITS architecture development process was the creation of functional requirements. A functional requirement is a description of what a system must do to address a regional need, to provide a regional service, and/or to facilitate a stakeholder's regional responsibility. In an ITS architecture, functional requirements focus on the high-level requirements needed to support regional integration. A functional requirement is characterized by naming the system, the stakeholder, and presenting a list of "shall" statements that constitute the functions to be provided by the system. Note also that the use of "shall" statements is deliberate as it sets forth a declarative statement about what a system needs to do.

In some instances, there are stakeholders who are not actively involved in the region but, because the region plans to use information consistently and because the National ITS Architecture identifies them as a subsystem, functional requirements for their systems have been included. Some examples of this are: California Department of Motor Vehicles, Media, and Private Truck Drivers. In these cases, although "shall" statements are used for consistency, it should be recognized that these functional requirements only characterize the capabilities as ones with which Bay Area agencies may have to interface. The region has identified some of the functions that come from these systems, but the region recognizes that it has no control or influence over the actual functional requirements of this system.

The list below (in alphabetical order by stakeholder) detail the primary functional requirements for the major ITS elements in the Bay Area. These functional requirements were developed based on specific information provided by the individual stakeholders about their respective system(s). Some of the regional ITS inventory elements include more than one stakeholder (i.e., Sub-regional and Local Cities and Counties). In some cases, when many stakeholders are grouped together, certain functional requirements have been noted as "if appropriate" or "as needed" to reflect the reality that limited system or interface capabilities may exist or be planned for one or more of the stakeholders in this element. Others have been noted as only being specific to certain stakeholders. Some capabilities may be provided at a later date, and some may never be provided, because of cost and operations and maintenance concerns.

An effort has been made to ensure that systems being implemented by Bay Area agencies should not be found inconsistent with the Bay Area Regional ITS Architecture just because they do not include all of the capabilities listed in this document. If a stakeholder decides to add additional functional capabilities than those reflected in a grouping and their system becomes unique in regional functions, then when the architecture is updated during the maintenance process, that stakeholder's element will be identified as a separate regional ITS element at that time and no longer part of a group.

Note that the National ITS Architecture does not require functional requirements to be developed for terminators. A terminator defines a boundary of the region and generally represents people, other systems, and the general environment that interface to the regional ITS. In the case of the Bay Area, the following entities are terminators and therefore do not have functional requirements attached to them as

part of this Regional ITS Architecture: Rail Operations, Call Boxes, Financial Institutions, 911Call Centers, Archived Data Administrators, and Kiosks.

Stakeholder: **California Department of Motor Vehicles**
System: **CVO Administration (PrePass)**

This system shall:

- provide administrative capabilities including database management and administrator-to-roadside and administrator-to-administrator interfaces.
- manage the electronic credentials database for a state and interface with roadsides performing credential checks.
- communicate and coordinate with other state commercial vehicle administrations.
- collect and store information on commercial vehicles.
- support the exchange of safety and credentials data among jurisdictions.
- support the exchange of safety and credentials data between agencies (for example, an administrative center and the roadside check facilities) within a single jurisdiction.
- ensure that safety criteria are available for automated roadside safety checks.
- collect and review carrier safety data and determine the carrier safety rating based on supplied criteria.

Stakeholder: **California Highway Patrol**
System: **CHP Computer Aided Dispatch**

This system shall:

- receive 9-1-1 and 7-digit local access calls and forward to appropriate dispatch center.
- receive information about incident from CHP vehicles.
- store incident information.
- provide incident data to operations personnel.
- dispatch emergency vehicles to an incident.
- develop and manage incident response plans.
- provide information about incidents to other systems that formulate and manage incident response.
- provide transportation information to TravInfo.
- track the availability of resources and assist in the appropriate allocation of resources for a particular incident response.
- provide coordination between multiple allied agencies before and during incidents to implement incident response plans and track progress through the incident.
- track and manage FSP tow trucks.
- request alerts on appropriate dissemination devices.
- maintain and update a web site showing CHP-responded incidents.
- perform administrative functions such as accounting, monitoring, and statistics development.

Stakeholder: **California Highway Patrol**
System: **CHP Vehicles**

This system shall:

- provide two-way communications to support incident response.
- receive dispatch and routing information.

- provide two-way communications to support vehicle tracking.
- send incident information to CAD system.
- preempt signals via short-range communication directly with traffic control equipment at the roadside.

Stakeholder: **California Department of Transportation District 4**
System: **Bay Area Incident Response System (BAIRS)**

This system shall:

- schedule maintenance and construction activities
- report maintenance and construction activities and status to TravInfo and FSP.
- manage maintenance and construction resource needs.
- collect and store roadside equipment status.
- manage maintenance and construction map data.
- operate infrastructure monitoring devices.
- track maintenance and construction vehicles.

Stakeholder: **California Department of Transportation District 4**
System: **Caltrans D4 Maintenance Vehicles**

This system shall:

- receive dispatch and routing information.
- provide two-way communications to support vehicle tracking.
- provide two-way communications to support coordinated incident response.

Stakeholder: **California Department of Transportation District 4**
System: **Caltrans D4 Transportation Management System**

This system shall:

- collect and provide electronic access to transportation information for Caltrans operator.
- monitor and diagnose field equipment remotely to detect failures, issue problem reports, and track the repair or replacement of the failed equipment.
- control systems for freeway management including integration of surveillance information with freeway geometry, vehicle control such as ramp metering, electronic signage, and highway advisory radio.
- interface to coordinated traffic systems, including the Smart Corridors
- monitor Caltrans owned/maintained signals.
- detect, analyze, reduce, and verify collected data from traffic surveillance equipment.
- formulate the development and management of incident responses.
- facilitate the dispatch of emergency response and service vehicles as well as coordinate response with all appropriate agencies.
- communicate with other TMCs to receive and transmit traffic information to other jurisdictions within the region, as appropriate.
- provide transportation information to PeMS.
- provide transportation information to TravInfo.
- manage reversible lanes.
- support joint control of field devices.
- process traffic data for advisory messages.
- provide traffic broadcast messages to devices such as CMS and HAR.

- provide web based traveler information system.
- provide Information Service Providers with a transportation information data interface.

Stakeholder: **California Department of Transportation District 4**
System: **Caltrans D4 TMC Roadside Equipment**

This system shall:

- monitor and report traffic flow.
- monitor surveillance and roadside equipment and interfaces and report detected abnormal conditions.
- display traffic information on equipment along the roadway.
- control freeway operation through ramp metering and reversible lane operation.

Stakeholder: **California Department of Transportation - Headquarters**
System: **CVO Weigh Stations (PrePass)**

This system shall:

- document violations and forward the information to the commercial vehicle if possible and to the commercial vehicle administration for processing.
- communicate two-way with approaching properly equipped commercial vehicles at mainline speeds.
- read tags for automated vehicle identification and credential checking.
- screen all vehicles, not just those that are equipped with tags.
- process data from commercial vehicle along with database information to determine whether a pull-in message is needed.
- generate random pull-in messages with provisions for facility operators and enforcement officials to have manual override capabilities.
- automate the roadside safety inspection process including the use of hand held devices to rapidly inspect the vehicle and driver.
- automate the roadside safety inspection process including the support of automated mainline speed reading of on-board safety data to rapidly screen the vehicle and driver.
- collect, store, maintain, and provide safety data and access historical safety data after receiving identification from vehicles at mainline speeds or while stopped at the roadside.
- write the results of screening and summary safety inspection back onto a tag.
- process safety data and issue pull-in messages or provide warnings to the driver, carrier, and enforcement agencies.
- perform roadside high speed weigh in motion.

Stakeholder: **Cities with Transportation Management Centers**
System: **Transportation Management System**

This system shall:

- monitor and manage the traffic flow at signalized intersections and mid-block locations.
- analyze and reduce the collected data from traffic surveillance equipment.
- develop and implement control plans for signalized intersections.
- generate status requests and control plan updates.
- detect and verify incidents.
- formulate the development and management of incident response plans.

- analyze, control, and optimize area-wide traffic flow.
- communicate with other signal systems/TMCs to receive and transmit traffic information to other jurisdictions within the region, as appropriate.
- provide traffic related data to operations personnel or other data users.
- receive and transmit transportation information to TravInfo.
- monitor and diagnose field equipment remotely to detect failures, issue problem reports, and track the repair or replacement of the failed equipment.
- allow joint control of field devices
- provide Information Service Providers with a transportation information data interface.
- process traffic data for advisory messages.
- provide traffic broadcast messages.
- support use of TransLink for non transit purposes (such as for parking).

Stakeholder: **Cities with Transportation Management Centers**
System: **Traffic Management Center Roadside Equipment**

This system shall:

- monitor and report traffic flow.
- monitor surveillance and roadside equipment and interfaces and report detected abnormal conditions.
- control traffic signals.
- receive vehicle signal priority requests.
- send requests to traffic signal controllers accordingly.
- display traffic information on equipment along the roadway.
- manage roadway traffic at highway-rail intersections.
- provide pre-emption of signalized intersections when activated.

Stakeholder: **Media**
System: **Media**

This system shall:

- collect, process, and disseminate traveler information such as congestion, incidents, special events, road closure, detour routing, weather, parking, and roadway maintenance information.
- maintain a database of local area transportation services available to travelers with up-to-the-minute information.
- provide users with real-time travel related information en-route to assist the travelers in making decisions about trips.
- provide interactive traveler information.
- send formatted traffic advisories including information concerning available travel options and their availability, and congestion information.
- provide the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, and special events.
- provide information tailored for individual users.

Stakeholder: **Metropolitan Transportation Commission**
System: **Bay Area Call Box Answering Center**

This system shall:

- receive calls from call boxes.

- collect available information about the caller and the reported incident.
- collect information on equipment status.
- provide transportation information to other systems or private parties that formulate and manage the response.
- collect and store transportation information that is collected in the course of day to day operations.
- provide data to operations personnel.
- assist in coordination between multiple allied agencies before and during emergencies and non-emergencies to implement incident response plans and track progress through the incident.

Stakeholder: **Metropolitan Transportation Commission**
System: **Freeway Service Patrol Computer System**

This system shall:

- track vehicles.
- provide incident personnel interface.
- perform administrative functions such as accounting, monitoring, and statistics development.
- record and store data for management purposes which is transferred to partner agencies.
- transmit vehicle location data to Caltrans BAIRS system and the CHP CAD system.

Stakeholder: **Metropolitan Transportation Commission**
System: **Freeway Service Patrol Tow Trucks**

This system shall:

- provide information to a central system to allow for vehicle tracking.
- provide a direct interface between the incident vehicle and incident management personnel.
- provide two-way communications to support coordinated response to incidents.

Stakeholder: **Metropolitan Transportation Commission**
System: **Regional Transit Information System**

This system shall:

- collect and process transit information such as schedules, routing, fares, etc. from all transit operators in the Bay Area and TransLink.
- provide schedule and itinerary information to the public and other transit operators.
- provide web based schedule and real time transit information to the 511 System.

Stakeholder: **Metropolitan Transportation Commission**
System: **TransLink Central System**

This system shall:

- manage, administer, and update the system providing transit fare products and value useable on all participating transit agency vehicles/systems.
- provide central clearinghouse for processing transactions electronically from participating transit agencies.
- verify validity of transactions.
- communicate with TransLink field equipment to receive and transmit data
- provide reports and transaction data to participating transit agencies.
- support non transit purposes such as parking.

- support connection to banking/credit facilities.
- monitor and diagnose field equipment remotely to detect failures, issue problems reports, and track the repair of failed equipment replacement.
- manage inventory and configuration of field equipment.

Stakeholder: **Metropolitan Transportation Commission**
System: **TransLink Field Equipment**

This system shall:

- collect information for managing and administering the system providing transit fare products and value useable on all participating transit agency vehicles/systems.
- provide information to the TransLink Central System.
- support the use of a single transit fare card across multiple transit systems.
- provide the capability to implement variable pricing structures.
- provide a confirmation of the transaction and card value information to each customer.
- collect transit fares electronically from customers.

Stakeholder: **Metropolitan Transportation Commission**
System: **511 System**

This system shall:

- receive data from TravInfo and Regional Transit Information Systems.
- provide Information Service Providers with a transportation data interface.
- provide information tailored for individual users.
- provide web based traveler information.
- provide telephone based traveler information.

Stakeholder: **Metropolitan Transportation Commission**
System: **TravInfo and Regional Archive System**

This system shall:

- provide transportation data retrieval interface.
- collect transportation data from roadside equipment and other agencies.
- provide 511 System with transportation data.
- provide Information Service Providers with a transportation data interface.
- provide public agencies with transportation data.
- collect, process, and store transportation information.

Stakeholder: **Metropolitan Transportation Commission**
System: **TravInfo Roadside Equipment**

This system shall:

- monitor and report traffic flow.
- monitor roadside equipment and interfaces and report detected abnormal conditions.

Stakeholder: **Partners for Advanced Transit and Highways**
System: **Performance Monitoring System (PeMS)**

This system shall:

- collect, integrate, and store transportation data from multiple sources.

- provide advanced data analysis, predictions, summarization, and mining features that facilitate discovery of information, patterns, and correlations in large data sets.

Stakeholder: **Private Truck Drivers**
System: **Commercial Vehicles**
This system shall:

- provide commercial vehicle driver communications.
- communicate commercial vehicle on-board data to roadside.
- collect on-board commercial vehicle sensor data.
- communicate commercial vehicle on-board data to vehicle manager.
- process vehicle location data.

Stakeholder: **Smart Corridor Partnerships**
System: **Information Service Provider**

This system shall:

- provide Information Service Providers with a traffic data interface.
- provide transportation data retrieval interface.
- receive and process transportation data from other systems.
- provide public agencies with transportation data.
- send formatted traffic advisories including information concerning available travel options and their availability, and congestion information to field equipment and user personal computing devices.
- provide information tailored for individual users.
- provide web based traveler information.

Stakeholder: **Smart Corridor Partnerships**
System: **Transportation Management System**

This system shall:

- monitor and manage the traffic flow at signalized intersections.
- analyze and reduce the collected data from traffic surveillance equipment.
- develop and implement control plans for signalized intersections.
- generate status requests and control plan updates.
- detect and verify incidents.
- formulate the development and management of incident response plans.
- analyze, control, and optimize area-wide traffic flow.
- communicate with other signal systems/TMCs to receive and transmit traffic information to other jurisdictions within the region, as appropriate.
- provide traffic related data to operations personnel or other data users.
- provide transportation information to TravInfo.
- receive periodic status updates in the absence of a request or asynchronously in the event of a detected failure or other unsafe condition at the intersection.
- monitor and diagnose field equipment remotely to detect failures, issue problem reports, and track the repair or replacement of the failed equipment.
- support joint control of field devices.
- monitor highway-rail intersection equipment at the roadside.
- provide Information Service Providers with a transportation information data interface.
- process traffic data for advisory messages.

- provide traffic broadcast messages.
- support use of TransLink for non transit purposes (such as for parking).
- support Smart Corridor Partnerships Information Service Provider function.

Stakeholder: **Smart Corridor Partnerships**
System: **Roadside Equipment**

This system shall:

- monitor and report traffic flow.
- monitor surveillance and roadside equipment and interfaces and report detected abnormal conditions.
- control traffic signals.
- receive vehicle signal priority requests and send requests to traffic signal controllers accordingly.
- display traffic information on equipment along the roadway.
- manage roadway traffic at highway-rail intersections.
- provide pre-emption of signalized intersections when activated.

Stakeholder: **Sub-regional and Local Cities/Counties**
System: **Police, Fire, Sheriff Departments and Emergency Services Center**

This system shall:

- receive emergency calls including 9-1-1 and 7 digit local access.
- receive information about incident from call.
- store incident information.
- provide incident data to operations personnel.
- dispatch emergency vehicles to an incident.
- develop and manage incident response plans.
- provide information about incidents to other systems that formulate and manage incident response.
- provide transportation information to TravInfo.
- track the availability of resources and assist in the appropriate allocation of resources for a particular incident response.
- request alerts on appropriate dissemination devices.

Stakeholder: **Sub-regional and Local Cities/Counties**
System: **Police, Fire, and Sheriff Emergency Vehicles**

This system shall:

- provide two-way communications to support incident response.
- receive dispatch and routing information.
- provide two-way communications to support vehicle tracking.
- preempt signals via short range communication directly with traffic control equipment at the roadside

Stakeholder: **Sub-regional and Local Cities/Counties**
System: **Traffic Operations Systems**

This system shall:

- monitor and manage the traffic flow at signalized intersections.
- analyze and reduce the collected data from traffic surveillance equipment.
- develop and implement control plans for signalized intersections.
- generate status requests and control plan updates.
- communicate with other signal systems/TMCs to receive and transmit traffic information to other jurisdictions within the region, as appropriate.
- provide traffic related data to operations personnel or other data users.
- provide transportation information to TravInfo.
- receive periodic status updates in the absence of a request or asynchronously in the event of a detected failure or other unsafe condition at the intersection.
- monitor and diagnose field equipment remotely to detect failures, issue problem reports, and track the repair or replacement of the failed equipment.
- provide Information Service Providers with a transportation information data interface.
- process traffic data for advisory messages.
- provide traffic broadcast messages.
- support use of TransLink for non transit purposes (such as for parking).

Stakeholder: **Sub-regional and Local Cities/Counties**
System: **Traffic Operations Roadside Equipment**

This system shall:

- monitor and report traffic flow.
- monitor surveillance and roadside equipment and interfaces and report detected abnormal conditions.
- control traffic signals.
- receive vehicle signal priority requests and send requests to traffic signal controllers accordingly.
- display traffic information on equipment along the roadway.
- manage roadway traffic at highway-rail intersections.
- provide pre-emption of signalized intersections when activated.

Stakeholder: **Toll Agencies** *(includes Caltrans District 4, GGBHTD, MTC/BATA)*
System: **FasTrak System**

This system shall:

- process tolls collected electronically from toll tags.
- coordinate with central toll collection administration (Caltrans, GGBHTD).
- operate central toll collection administration (MTC/BATA).
- operate and maintain toll collection and monitoring equipment.

Stakeholder: **Toll Agencies** *(includes Caltrans District 4, GGBHTD, MTC/BATA)*
System: **FasTrak Toll Equipment**

This system shall:

- collect tolls electronically from motorists using toll bridges.
- provide the capability to implement variable pricing structures.
- process electronic toll collection without the customer stopping.
- provide a confirmation of the transaction to each customer.
- record images of violators.

Stakeholder: **Transit Operators/Agencies**
System: **Message Station System**

This system shall:

- collect transit travel data from the central system.
- display traveler with transit information at stations, stops, and other public transportation areas.
- display formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information.
- provide information to users at transit stops before they embark.

Stakeholder: **Transit Operators/Agencies**
System: **Next Vehicle Arrival System**

This system shall:

- support the collection and processing of vehicle location data.
- provide vehicle location data to message signs.
- provide vehicle location data to transit agency traveler information systems.
- provide vehicle location data to the transit operations system.

Stakeholder: **Transit Operators/Agencies**
System: **Transit Operations System**

This system shall:

- support use of TransLink for all applicable regional transportation services.
- provide transit users the means to obtain transit fare products and reload value useable on all participating transit agency vehicles/systems.
- support the use of remote field equipment to process TransLink transactions.
- allow two-way voice communication between the transit vehicle driver and a facility; two-way data communication between the transit vehicles and a facility; transmission of sensor data from the transit vehicles to a facility; and data transmission from individual facilities to a central facility for processing/analysis.
- monitor transit vehicle locations and determine vehicle schedule adherence.
- collect and store transit information that is collected in the course of transit operations.
- provide transit data to operations personnel.
- support advanced maintenance functions for the transit property.
- collect operational and maintenance data from transit vehicles, manage vehicle service histories, and monitor drivers and vehicles.

- provide information to proper service personnel to support maintenance activities and record and verify that maintenance work was performed.
- automate and support the assignment of transit vehicles and drivers to enhance the daily operation of a transit service.
- provide information to customers at major transit stops and other public transportation areas before they embark and provide similar information onboard (if applicable) once they are enroute.
- support schedule coordination between transit properties.
- collect data required to determine accurate ridership levels and support fare structures.
- provide transportation information to TravInfo.
- provide transportation information to the Regional Transit Information System.

Stakeholder: **Transit Operators/Agencies**
System: **Transit Vehicles**

This system shall:

- track transit vehicle and transmit location to dispatch.
- support two-way voice communication between the transit vehicle driver and a facility; two-way data communication between the transit vehicles and a facility; and transmission of sensor data from the transit vehicles to a facility.
- support use of TransLink for all applicable regional transportation services.
- use transit vehicle data to automatically generate preventative maintenance schedules for each vehicle by utilizing vehicle tracking data and storing with a trip computer.
- request signal priority from roadside equipment, as appropriate.
- monitor the safety of transit vehicles using onboard safety sensors, processors and communications from onboard system to operations center.
- collect data required to determine accurate ridership levels and support fare structures.
- monitor vehicle performance and report abnormal conditions.

Stakeholder: **Traveling Public Commuters at Large**
System: **Personal Vehicles with Toll Tags (FasTrak)**

This system shall:

- enable transponder identification for tolling purposes.
- support static and high speed reading by roadside and overhead equipment.
- support measurement of link travel times.

Stakeholder: **Traveling Public Commuters at Large**
System: **User Personal Computing Devices**

This system shall:

- provide capability for travelers to receive formatted traffic advisories from their homes, place of work, major trip generation sites, personal portable devices, and over multiple types of electronic media.
- provide basic routing information and allow users to select those transportation modes that allow them to avoid congestion, or more advanced capabilities to allow users to specify those transportation parameters that are unique to their individual needs and receive travel information.
- provide capabilities to receive route planning from the infrastructure at fixed locations such as in their homes, their place of work, and at mobile locations such as from personal portable

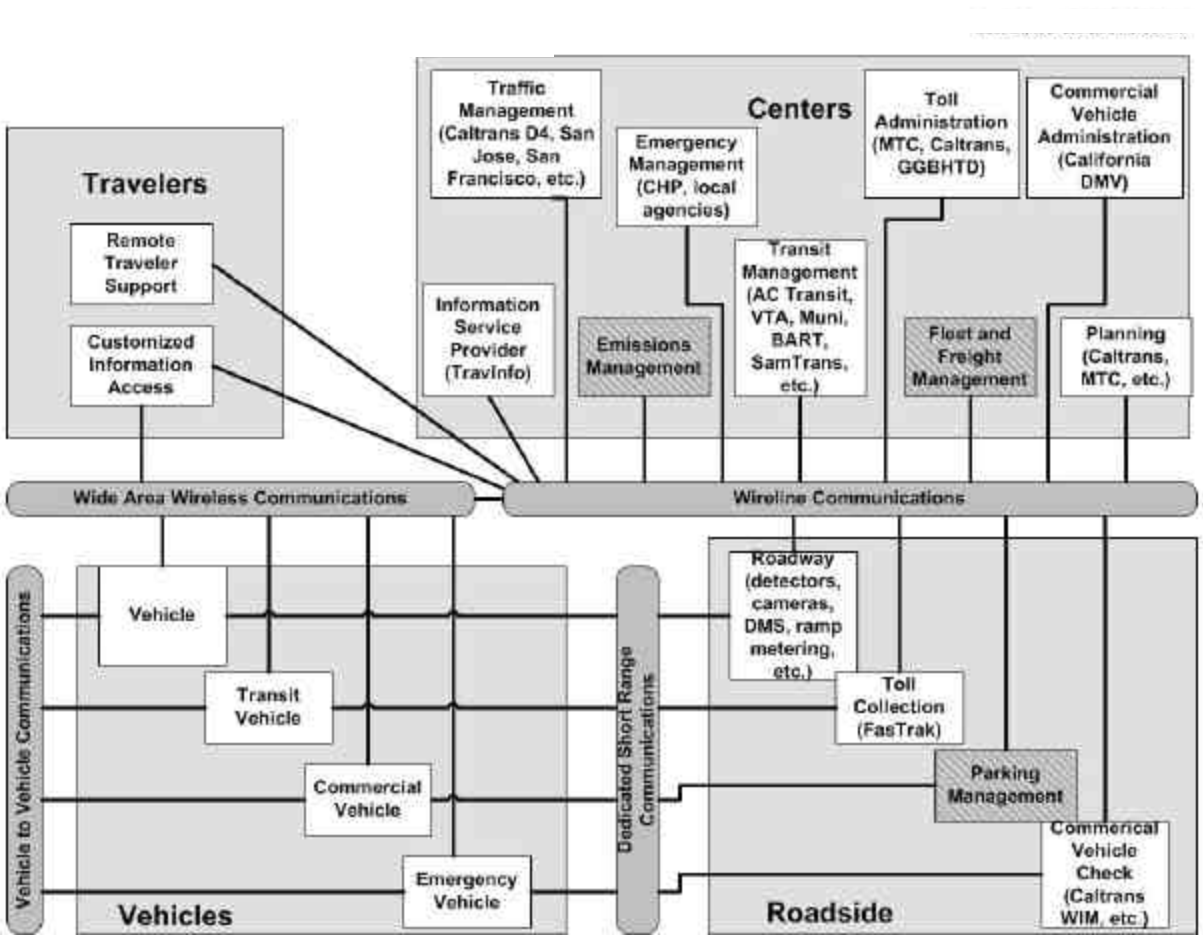
devices and in the vehicle or perform the route planning process at a mobile information access location.

8.0 High-Level Architecture

The ITS inventory, services, operational concepts, and functional requirements lay the groundwork for evaluation of which systems need to be connected in the Bay Area. Based on this information, the interconnects and information flows for ITS in the Bay Area were developed.

The Bay Area ITS interconnects were first mapped to the National ITS Architecture using the National ITS Architecture high-level diagram. This diagram depicts all of the ITS subsystems identified in the National ITS Architecture and the basic communication channels between these subsystems. Figure 3 shows the relevant subsystems identified for the Bay Area. The boxes with gray shading and diagonal lines are subsystems that are not part of the region's existing or planned deployment.

Figure 3: Bay Area High-Level Architecture Diagram



Note: ▭ denotes systems not part of the region's existing or planned deployment

Figure 4 presents an overall high-level conceptual representation of the Bay Area Architecture. This diagram was derived based on the inventory analysis, the involved market packages, and an understanding of stakeholder needs. Also, due to the sheer size of the number of diagrams represented by the Bay Area ITS Architecture interconnects and information flows, a separate document has been compiled and is offered as Appendix G to this document.

9.0 Relevant Standards

ITS standards are fundamental to the establishment of an open ITS environment, a goal originally envisioned by the USDOT, and, as such, are an important component of the information flows in a regional ITS architecture. Standards facilitate deployment of interoperable systems at local, regional, and national levels without impeding innovation as technology advances and new approaches evolve.

Establishing regional and national standards for exchanging information among ITS deployments is important not only from an interoperability point of view, but it also reduces risk and cost since a region can select among multiple vendors for products and applications. Standards allow competition, create better products, and lower prices. Use of standards can also limit product obsolescence and extend the effective life of an ITS investment.

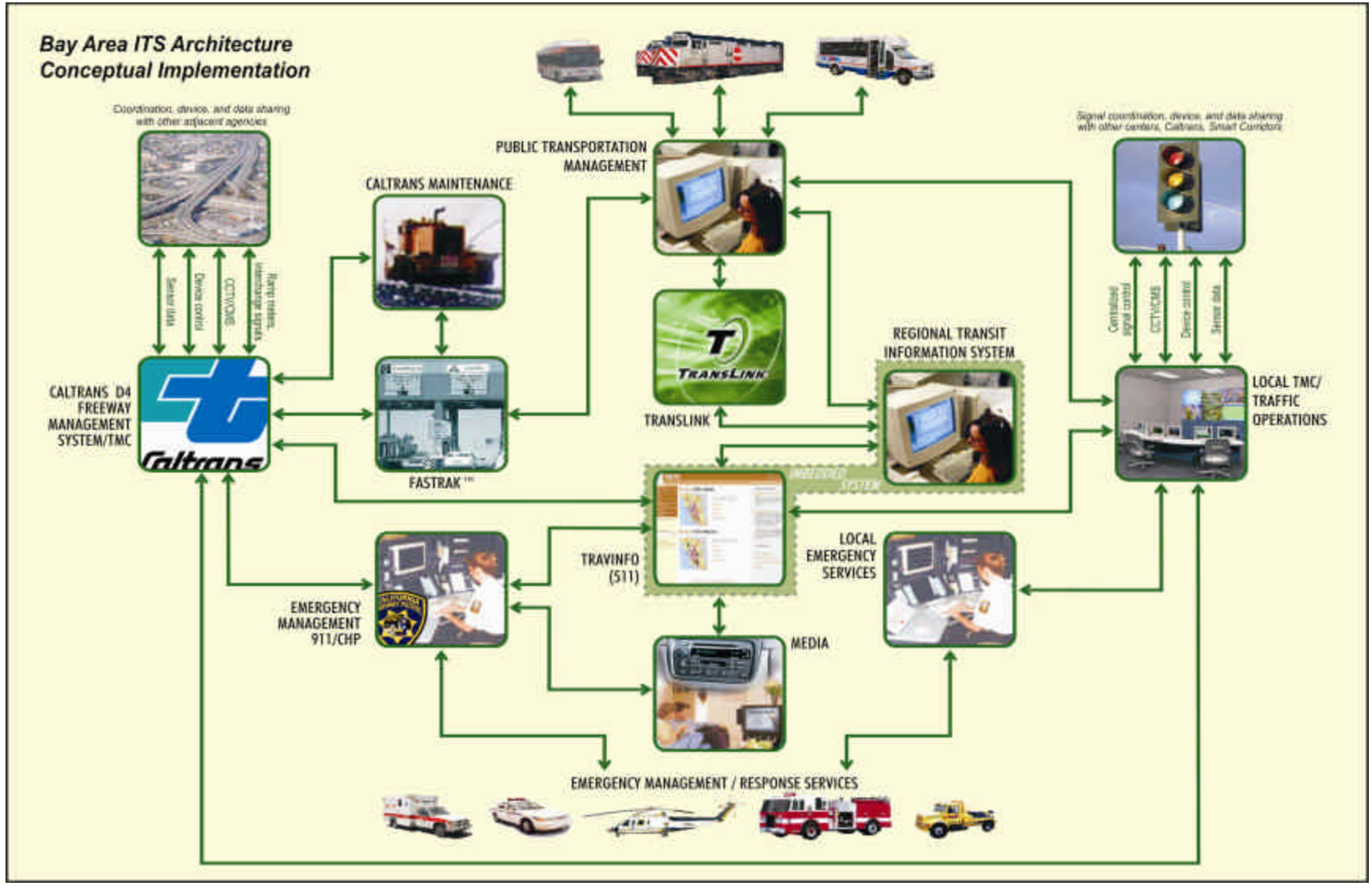
There are currently over 80 ITS standards, but not all standards will be used in most regions. Even within a region, not all agencies will use standards. In order to conform to federal requirements, the regional ITS architecture is required to reference those standards that are applicable to the region's ITS elements and interconnects. For many elements and interconnects, there is more than one standard that may be selected, which can result in similar deployments (e.g. TMCs) using different standards (e.g., DATEX, CORBA, and XML). Even if similar standards are used (e.g. DATEX or the standard for changeable message signs), they may not use the same data dictionary and may also be different versions. This in turn will require translators or custom software to allow these systems to interconnect. Therefore, as part of strategic activities, the Bay Area may want to go beyond the federal requirements and in certain specific areas (e.g., Center-to-Center Systems) select a specific standard or a short list of standards to ensure and promote interoperability.

The standards that are most widely applicable to ITS deployments are the National Transportation Communications for ITS Protocol (NTCIP) family of standards. NTCIP is a joint product of the National Electronic Manufacturers Association (NEMA), the American Association of State Highway and Transportation Officials (AASHTO), and the Institute of Transportation Engineers (ITE).

NTCIP is a family of communication protocols* and data definition standards that have been designed for use in all types of systems dealing with the transportation environment, including those for freeways, traffic signals, emergency management, traveler information, and data archiving. It has been adopted by the Federal Highway Administration (FHWA) to meet the needs and requirements for ITS communication and to insure that inter-network connectivity is done through industry standard interfaces.

* A protocol is a set of formal rules describing the format and transmission of data. The devices at each end of a given communication link must use the same protocol in order to communicate.

Figure 4: San Francisco Bay Area Architecture Conceptual Implementation



NTCIP standards provide both the rules for communicating and the vocabulary necessary to allow electronic traffic control equipment from different manufacturers to operate with each other as a system. NTCIP is the first set of standards for the transportation industry that allows traffic control systems to be built using a mix and match approach with equipment from different manufacturers. As a corollary, in the past, when a buyer purchased a stereo from one manufacturer, the buyer also had to purchase speakers and attachments from the same manufacturer. Today, the stereo industry is basically plug and play or mix and match. It is one of the most successful examples of effective use of standards. The transportation industry, although not there yet, is trying to evolve to the same level of interoperability.

The proper use of NTCIP standards is important for several reasons:

- NTCIP influences design requirements such as interchangeability/interoperability, Internet protocol (IP) addressability, and ease of integration.
- NTCIP offers increased flexibility and eliminates barriers to interagency coordination by reducing the need for reliance on specific equipment vendors and customized one-of-a-kind products.
- NTCIP allows a management system to communicate with a mixture of device types over the same communications channel.
- NTCIP also allows the future expansion of the system to benefit from true competitive bidding, as well as allow other types of ITS elements to be added.

9.1 Standards Development Organizations

The ITS community recognized the advantages of standards and encouraged Standards Development Organizations (SDOs) to create ITS standards between the most critical ITS interfaces. The following is a list of SDOs that are developing ITS standards. This list provides acronyms that show up repeatedly throughout the list of regional appropriate standards:

- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- Electronic Industries Alliance (EIA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Institute of Transportation Engineers (ITE)
- Society of Automotive Engineers (SAE)
- National Transportation Communications for ITS Protocol (NTCIP)

9.2 Stages of Development of a Standard

It's important to understand at what stage, in the typical development cycle, the standard is in, especially if a stakeholder is considering the inclusion of specific standards in procurement specifications. Early in the standards development cycle, there are many changes before approval or publishing. In fact, many standards have yet to undergo testing or initial deployment.

There are numerous levels of maturity or stages of development for standards:

- Draft Under Development. During this phase, there are significant changes likely to occur.
- Draft for Ballot or in Balloting. Standards being voted upon by a committee or working group or are undergoing other SDO procedures.

- Approved. Standards that have passed all necessary ballots and have been approved by an SDO, but have not yet published.
- Published. Standards available for purchase and use.
- Tested/Deployed Standard. Only minor changes are likely to occur in this phase of a standard development. (In reality, as many of these standards, such as those for changeable message signs, are being implemented, major changes have been implemented due to their first time use.)

Due to the changing nature of standards, stakeholders are strongly encouraged to check on the maturity of an ITS standard, either as recommended in this document or elsewhere, during the project planning process. The maturity status of standards can be obtained from www.its-standards.net. Other information that can be obtained from this website are pointers to general information, including status charts for each ITS standard, web links, standards deployments, and standards training courses.

9.3 ITS Standards in Procurement Specifications

The use of ITS standards in procurement specifications often depends on how much risk can be afforded. There are often significant changes to an early standard and even some risk of change in a balloted standard. Also, early deployers will likely have suggested improvements to the standard that will require an update via an amendment to the standard (amendments do typically pass through the process more quickly).

There is currently an FHWA Testing Program underway to speed up testing of ITS Standards at the website noted above. Other information also available includes:

- ITS Standards Testing: shows which standards are being tested, test site information, testing approach, and status
- ITS Standards Fact Sheets: one page, user-friendly, easy to understand summaries of many of the ITS standards

9.4 Decision-Making Strategy for Standards

Making the best choices for standards depends on multiple factors, including throughput (how much data must be transmitted or received on the interface), network topology (how the ITS elements are connected together), and infrastructure (fiber optic lines, leased land lines, etc.), among others. The exact process for making this decision regionally will be a function of the Bay Area Architecture Maintenance Team.

Briefly, the process consists of stakeholders (or the Maintenance Team) identifying proposed modifications to the selected standards and the Maintenance Team reviewing the modifications. If the modifications impact other stakeholders, then, their opinion will be sought. A consensus of those involved will determine if the change to any selected standard warrants application to the Bay Area architecture.

In determining when and how to incorporate ITS standards for a given interface, it's critical to understand the relative maturity of the standards. Currently, many of the exact standards for specific deployments have not been decided, but the process for making those decisions are beginning to be developed. For each potential standard, consider asking:

- Has the ITS standard been approved or published by the SDOs?

- Has the ITS standard been adopted by multiple vendors?
- Has the ITS standard been tested, whether informally by the vendor, or through the formal ITS Standards Testing Program funded by FHWA?
- Is there an amendment to the ITS standard currently in the works, and if so, how much of the standard will change as a result?
- Has the standard been used in an actual implementation?

Although the Bay Area should create a plan to migrate toward ITS standards conformance, stakeholders should reach consensus on an interim approach if the ITS standards applicable to the region's interfaces are not yet mature. The interim approach however should be supported to some extent by the industry to avoid ending up with a proprietary standard only supported by a few manufacturers. This activity will be addressed later in this document under Section 13, Regional Perspectives.

9.5 ITS Standards in the Bay Area

A key component of a regional architecture is the ability to exchange information between control centers and between devices. Additionally, a frequent requirement is to allow for joint control of field devices such as cameras and changeable message signs. To be able to do this, however, requires the use of communications protocol that can be understood at each end of the transmission. Common protocols such as NTCIP are recommended for use in the Bay Area. Additionally, other standards such as those for location referencing where all systems can comprehend each other's location referencing system are necessary. The following sections expand on the recommended standards for the Bay Area.

Use of NTCIP in the Bay Area

A primary purpose of NTCIP is to handle two major ITS communication needs: (1) Center-to-Field Communication and (2) Center-to-Center Communication. Additionally, NTCIP may also address Field-to-Field Communications at some point, but this has not occurred yet.

Center-to-Field communication refers to the communication between a management system or center and multiple control or monitoring devices managed by that system or center. This type of communication typically involves roadside devices. Examples of Center-to-Field include:

- A traffic signal management system located at a TMC communicating with traffic signal controllers at intersections.
- A traffic management system controlling Pan/Tilt/Zoom Closed Circuit Television cameras and changeable message signs.
- A transit management center polling transit vehicles for their current location.

While an argument can be made for standardization of the interface to the various field devices throughout the Bay Area, it is not critical that this be done. The reason being that an agency accessing data or control of a device owned/operated by another agency will most likely go through the "owning" agency's traffic management center. In that instance, Center-to-Center communications is more critical as is discussed further below.

Center-to-Center communication involves the communication between two or more central management systems. Examples of Center-to-Center communication applicable to the Bay Area Regional Architecture include:

- Two or more traffic signal management systems exchanging information (including second-by-second status changes) to achieve coordinated operation of traffic signals managed by the different systems and to enable personnel at one center to monitor the status of signals operated from another center.
- Sharing of transportation related information with other Bay Area agencies such as TravInfo.
- Providing traffic signal priority for selected (e.g., behind schedule) transit vehicles.
- Posting a warning message on another agency's changeable message sign.

The NTCIP Center-to-Center protocols are particularly relevant as they allow agencies to exchange information, to monitor conditions in other agencies' systems, and to implement coordinated responses to incidents and other changes in field conditions when needed. Such data exchange and coordinated response can be implemented either manually or automatically. One agency can monitor, and issue basic commands to (if authorized) field devices operated by another agency, even though those devices may be from a different vendor than those used by the monitoring agency.

NTCIP Center-to-Center protocols are implemented currently though two standards: DATEX ASN (Data Exchange protocol/Abstract Syntex) and CORBA (Common Object Request Broker Architecture protocol). Both DATEX and CORBA are complicated to implement and require highly skilled staff for design, implementation, and maintenance. Several Bay Area agencies are working together to implement a DATEX-based Interim Center-to-Center Communications System for linking the TMCs. However, eXtensible Markup Language (XML) is also emerging as a Center-to-Center communications protocol. It has the advantage of being an industry wide standard (across all Microsoft Windows-based systems regardless of the application) and can be implemented relatively easily with "typical" information systems staff. In the interim, however, DATEX should be the protocol of choice in implementing Center-to-Center Communications in the Bay Area.

There are some types of data communication not currently addressed by the NTCIP family of standards. Other standards either currently exist or are in development for those purposes. As of the writing of this report, NTCIP standards are not ready for the following applications:

- A roadside device reading and/or writing to an electronic tag on a vehicle.
- Full motion video images transmitted from a camera or recorder media. Several industry standards already exist for this use, for example those of the National Television System Committee (NTSC). Additionally, NTCIP standards do cover the Center-to-Field transmission of video camera control commands and switch control data.
- Data transmission for devices owned by individual travelers. This includes wireless broadcast communication.
- In-cabinet communications between a controller and other electronic devices in a roadside cabinet. Requirements for such application, for example the Advanced Transportation Controller (ATC), will be addressed in the future ATC Cabinet standard, ATC Controller standard and the ATC Application Programming Interface (API) Standard.

Location Referencing Message Specification

Another important issue for the Bay Area deals with location referencing. A common method of referencing transportation links and nodes is essential for many of the ITS services involving cooperative processing between ITS subsystems. A common frame of reference is needed so that communications between systems can be rationally reduced to an unambiguous reference to the same transportation links, ramps, intersections, etc. A standard method for location referencing is being developed nationally and is called the Location Referencing Message Specification (LRMS). This does not necessarily imply the

need to use the same referencing system, but instead conversions are available to convert locations from one system to another.

The Society of Automotive Engineers SAE J2374 – Location Referencing Message Specification Information Report, also known as LRMS, defines a standard mechanism for the exchange of geographic location. These include:

- Address
- Cross Streets
- LinkID
- Longitude, Latitude
- Linear Reference (e.g. Milepost)

Location referencing systems in use in the Bay Area range from simple street address schemes to using TIGER files. Conversion from one to another will be extremely important in the future particularly as electronic connections are made to non-traffic control systems such as computer aided dispatch systems for emergency personnel and transit management systems. The development of a LRMS would be useful for the development transit automatic vehicle location (AVL) standards for the Bay Area.

A further complication arises from the type of data being exchanged. If the data is from an inductive loop, the location is fixed and a one time correlation of its location can be made. However, if the data is from a location that may be variable, such as an incident, the conversion of the location to the various location referencing systems will need to be made in real time. The concept of LRMS has not yet been defined for the Bay Area and future discussions will be needed on standardizing the exchange of location based data.

Transit Automatic Vehicle Location (AVL) Standards

In the development of the baseline architecture, the desire for some standardization of transit AVL systems was identified. The intent is not to standardize the individual systems themselves, but to develop a standard methodology for sharing vehicle location and other pertinent transit ITS data. The LRMS discussed above could resolve the vehicle location issue.

There is a suite of transit ITS standards that are in varying states of development, approval and update under the NTCIP umbrella. Information on the complete set of standards under the NTCIP umbrella (transit and non-transit) can be found on the NTCIP website: http://www.ntcip.org/. Another valuable resource is the Transit Standards Consortium (TSC). The TSC is an independent transit industry forum for facilitating comprehensive and integrated research, development, testing, training and maintenance of transit standards to improve transit services. The TSC also has a website with valuable information: http://www.tsconsortium.org

Two specific recommendations contained in the Bay Area ITS Plan could work towards achieving the development of transit AVL standards for the Bay Area. The first recommendation is Action Item #5, in Section 11 of this report. It recommends the development of a Transit ITS Working Group that could discuss and work to resolve issues such as development of transit standards for the Bay Area. The other specific recommendation is project # PT 1, in Table 8 of this report. It recommends a project to establish a common methodology to exchange automated vehicle location (AVL) data from transit vehicle systems of the various transit operators throughout the Bay Area region from a center-to-center perspective.

Applicable Incident Management Standards

Other applicable national ITS standards include those associated with incident management. By following national incident management standards throughout the Bay Area, a true multi-agency response to an incident is much more easily implemented. Applicable standards include:

- The ITE/AASHTO Advanced Traffic Management Data Dictionary (TMDD) provides a common definition in system engineering terms of data in a typical ITS. By using these terms throughout the various centers in the Bay Area, it will be possible to easily transmit and track incidents from their occurrence to their removal. Data elements for Special Events and Roadway Construction are also defined.
- The IEEE P1512 Message Sets for Incident Management Suite of Standards enables Transportation Management Centers (TMCs) to track in great detail the on-site management of an incident. This will be applicable when a TMC needs to coordinate with other TMCs in the region. It is also applicable to TMCs talking to one another when combined with the TMDD.
- NTCIP 1402 Transit Communications Interface Protocol - Incident Management (IM) Business Area Standard tracks an incident from the point of view – and needs – of the transit agency. In the event that Bay Area transit agencies implement this protocol, this will allow communications between the city/county TMCs and their counterparts in transit.

Each of the above noted standards have been adopted by their respective standards making organizations. As they are being implemented, it can be expected that further changes will be made in these standards. Additionally, in discussing national standards, note that these standards include those which were specifically developed for ITS and those which were developed for another technical area but which are still applicable. Standards associated with NTCIP comprise the bulk of those developed specifically for ITS. With respect to standards from other technical areas, the ones applicable include standard computer equipment interfaces (which are primarily those of the Institute of Electrical and Electronic Engineers) and those associated with CCTV (i.e. National Television System Committee standards for full motion video).

Standards for the Bay Area

ITS Standards address interfaces and information flows between systems. The set of standards for the Bay Area is based on the information flows, which were developed through a stakeholder consensus process. Appendix H presents the recommended relevant standards for each information flow within the Bay Area ITS Architecture. The standards consist of those developed by AASHTO/ITE/NEMA as well as ASTM, IEEE, ANSI, EIA/CEA, SAE and IEEE. Due to the length of this listing (about 200 pages), it is not attached to this document but is available as a separate file.

In reviewing and applying these standards, the following needs to be kept in mind:

- These standards only need to be applied where there will be an exchange of data or monitoring/control functions between systems.
- The specific standards listed are not static. As the standards are implemented, changes are being made. In addition, the standards are being changed as technology evolves. Typically, these changes result in standards that are backward compatible although new functionality may not be supported with the older versions of the relevant standard.

In order to find which standard impacts your system deployment, refer to the information flow diagrams in Appendix G to determine the name of the information flow. Using this name, the stakeholder can then review the alphabetical listing of the flows in Appendix H to determine which specific standard or

standard group is applicable to that flow. Standard groups will require additional review before they can be used. Specifically, the stakeholder will need to know which technology is being implemented (i.e. Ethernet, point to multipoint, etc.) and which standard center-to-center protocol (i.e. CORBA, DATEX, XML, etc.) is being implemented to determine specific applicable standards.

As previously noted, DATEX is the standard of choice for Bay Area systems that need to be interconnected. It should be noted however that the DATEX standard as defined for traffic control applications is undergoing changes as more implementations occur. Additionally, associated standards such as those for the Traffic Management Data Dictionary (TMDD) are also being changed due to ongoing implementations and as new data items are defined. As a result of these actions, it can be expected that some form of data translation will be required for the foreseeable future.

9.6 Standards Availability

Currently, ITS Standards are available directly from the SDOs. The NTCIP standards, for example, are available from NEMA, ITE, and AASHTO. According to ITE, ITS Standards are available for purchase as individual copies and as sets, where a set is a series of standards (i.e. the 1200 series). However, the purchase price does not allow copying of the standard, use by more than one entity concurrently, and does not include updates. Additionally, regionwide licensing is not available.

At one point, the US Department of Transportation was considering funding the maintenance efforts of the SDOs in maintaining the standards in which case the standards would be free to the SDO members. However, this action is on hold due to budget restraints. Members of SDOs can typically obtain a discount on the standards.

To ensure that the applicable standards are being utilized in the Bay Area, it is recommended the Maintenance Team, as defined in Section 13, be tasked with being the point of reference for all questions dealing with standards. Other standards activities for the Bay Area are also documented in Section 11, Regional Perspectives.

10.0 Regional Bay Area ITS Projects

The Bay Area is rich in ITS deployments. Many of these systems -- such as TravInfo, TransLink, SMART Corridors, Caltrans D4 TOS, to name just a few -- exist or are underway. The remainder of the full build-out of the Bay Area Regional ITS Architecture will be implemented through many individual ITS projects and private sector initiatives that occur over years, or even decades. In this step of the architecture development, a list of regional ITS projects are identified that assist in building out the architecture. In addition, the development of a sequence, or ordering, of the ITS projects that will contribute to the integrated regional transportation system depicted in the regional ITS architecture is defined. During this project identification process it was noted that operating and maintaining existing ITS is a high priority for the region. The appropriate emphasis should be placed on ensuring that existing ITS are fully funded throughout their life cycle.

Both the traditional planning process and the regional ITS architecture planning process have the same goal: to use local knowledge and a consensus process to determine the best sequence of projects to create a transportation network that meets the needs of the region. Translating this goal into a specific Bay Area focus results in the following objectives: to create an efficient list of ITS projects, to build out the ITS architecture, and to fill in system gaps, all based on regional needs, project readiness, and capacity to

deploy. The Bay Area stakeholders also recognize that development of this sequenced project list is a specific requirement of the FHWA ITS Architecture Rule and FTA Policy.

To be clear, the term "build-out of the architecture" refers to projects that deploy the system interconnections and information flows from a center-to-center perspective. Each "center" or central system may have many other functions or features that need to be explored as part of a robust system engineering process during project deployment, but the regional architecture does not capture that level of detail. The architecture is also not focused on technology or infrastructure solutions; architecture is technology-independent and the projects listed reflect this aspect by, again, capturing the needs for center-to-center system integration only.

The Bay Area project list does reflect technical projects derived from the "Bay Area ITS Deployment Key Issues for Action" which evolved from Phase 1 of this project and was captured in the "Phase 2 Focus Memorandum". Other actions resulting from these key issues are reflected in Section 11, Regional Perspectives.

The 1996 ITS Early Deployment Plan (EDP) for the San Francisco Bay Area was also reviewed in case there were any relevant projects to be captured. The EDP listed eight action plan items, each of which is well underway within the Bay Area. Therefore, no new projects were captured as a result of this review.

The development of the list of ITS projects for the Bay Area was performed in an iterative manner. The first step was to review the existing regional plans, collected as part of Phase 1 of the project, to find those ITS projects already planned and/or programmed in order to not be duplicative by including them in this plan. The following resources were reviewed:

- ITS Element of Santa Clara Valley Transportation Plan 2020, May 2001
- San Francisco Municipal Railway Short Range Transit Plan 2002-2021, October 2001
- SFgo Strategic Plan Project List, December 2001
- TEA-21: A Proven Record of Success, Annual Reports to Congress from MTC
- 2001 Regional Transportation Plan for the San Francisco Bay Area, November 2002
- Silicon Valley ITS Strategic Plan
- Traffic Operation Systems (TOS) Implementation Plan
- Freeway Concept of Operations Reports
- Draft 2004 Bay Area Regional Transportation Improvement Program (RTIP)
- and others

Then, the Bay Area Architecture was reviewed and projects created as follows:

- For planned, yet unprogrammed systems, a system deployment project was created.
- For planned, yet unprogrammed center-to-center system interconnects or information flows, an integration project was created.

In order for the Bay Area stakeholders to be able to stratify the project list into something more meaningful to their respective management structures and policy boards, the overall project list was broken into categories. First is a category for regional or cross-cutting projects, generally covering three different types of projects:

1. Projects that cover a broad geographic area of the nine county Bay Area
2. Projects that have been identified as being a need in the Bay Area, but without a positively identified "champion" or stakeholder to carryout a specific project of the type identified
3. Projects whose results benefit multiple counties and agencies within the Bay Area

In order to further categorize the projects into manageable classifications, the National ITS Architecture guidelines for ITS services, or market packages, was used. Market packages have been used as the initial list of ITS services by most regional architectures, as they provide a service-oriented view of the National ITS Architecture. A market package consists of a collection of one or more subsystems that can be linked together to form a service. Table 7 reflects stakeholder consensus on the particular Bay Area focus. These ITS market package categories have been used to further categorize the ITS projects resulting from the architecture effort. (Note that projects related to Commercial Vehicle Operations have been deferred to the Statewide Architecture effort.)

The last three market package categories, Archived Data Management, Maintenance & Construction Management, and Vehicle Safety, are a secondary focus in the region. Projects for these areas are not yet noted on the list. Archived Data Management can allow for better planning and predictive modeling; Maintenance & Construction Management can integrate weather, work zone, and construction data with freeway and traveler information systems; and planning for the use of Vehicle Safety systems such as intersection collision warning, mayday messaging, and advanced railroad crossings can enhance the regional safety goals.

Table 7: National ITS Architecture Market Package Categories

ITS Market Package Categories		
	Bay Area Focus	
	Primary Focus	**Secondary Focus**
Traffic Management	●	
Traveller Information	●	
Public Transportation	●	
Commercial Vehicle Operations	●	
Emergency/Incident Management	●	
Archived Data Management		●
Maintenance & Construction Management		●
Vehicle Safety		●

Table 8 presents the list of Bay Area ITS projects needed to build-out the regional ITS Architecture. This list is not meant to imply funding priorities, but rather a logical set of projects that facilitate center-to-center integration. Deployment of these projects will be the result of decisions made in the future during project planning processes.

Table 8: Potential Regional Bay Area ITS Projects

Project #	Project Description	Participating Agencies	Market Package( ) Addresse 1
Regional / Cross-Cutting			
REG 1	Integrate the Caltrans Transportation Management System with other traffic management systems around the Bay Area region, as appropriate, to allow for coordinated operations and information sharing; including the following: the various SMART Corridors throughout the Bay Area region, Local City/County traffic management systems, TravInfo, etc.	• Caltrans • Subregional Local Cities-Counties • SMART Corridor partner agencies • CHP • MTC • Others as appropriate	ATMS 1 ATIS 1
REG 2	Integrate the SMART Corridors throughout the Bay Area with other local traffic and transit management systems around the Bay Area region, as appropriate, to allow for coordinated operations and information sharing.	• Subregional Local Cities-Counties • SMART Corridor partner agencies • Transit agencies as appropriate • Others as appropriate	ATMS 1 APTS 7
REG 3	Conduct a project to evaluate and recommend a consistent region-wide methodology for deployment of transit signal priority and emergency vehicle pre-emption.	• MTC • Transit operators as appropriate • Subregional Local Cities-Counties • Caltrans	APTS 7
REG 4	Integrate transit operations/management system(s) of the various transit operators in the Bay Area region with other transit (bus and rail) and traffic management systems and centers, as appropriate, throughout the Bay Area region, to allow for coordinated operations and information sharing.	• Transit operators as appropriate • Subregional Local Cities-Counties • Caltrans • SMART Corridor Agencies • Others as appropriate	APTS 7
Traffic Management			
TM 1	Expand the Caltrans Traffic Operations System (TOS) throughout the Bay Area region from a geographic perspective in high priority corridors.	• Caltrans • Others as appropriate	ATMS 1

Project #	Project Description	Participating Agencies	Market Packages Addressed
TM 2	Expand and modify the functionality of the Caltrans Traffic Operations System (TOS) to include: highway speed monitoring, field device monitoring and control, reversible lane monitoring, weather monitoring (environmental) monitoring, en-route traveler information dissemination, emissions monitoring, and vehicle probe data acquisition.	• Caltrans • Others as appropriate	ATMS 1 ATMS 2 ATMS 4 ATMS 6 ATMS 8 ATMS 11 ATMS 18 ATMS 19 MCO 3
TM 3	Implement Freeway Ramp Metering in corridors where congestion and ramp volumes warrant. The Caltrans/CHP TMC should have the capability to monitor and /or control the ramp metering functions from the TMC.	• Caltrans • CHP • Other local agencies as appropriate	ATMS 4
TM 4	Deploy high priority traffic signal system interconnections across jurisdictional boundaries, as appropriate.	• Subregional Local Cities-Counties • Smart Corridor Agencies • Others as appropriate	ATMS 7
TM 5	Develop and implement local TOCs/TMCs, either individually or jointly with other neighboring agencies. These projects would develop local agency (city and county level) TOCs/TMCs with varying levels of capability depending on the needs of the deploying local agency, or agencies. Joint centers would likely follow the SMART Corridor Paradigm. These projects would allow for command and control of the field assets of each individual agency as well as the ability to share data and or information with other agencies on an as needed basis. Shared control of field assets would be voluntary on an agency by agency basis.	• Local cities and county agencies as appropriate • Others as appropriate	ATMS 1 ATMS 3 ATMS 6 AD 1
TM 6	Conduct projects to update signal timing, coordination, and synchronization on a periodic basis to account for changes in population, traffic volumes, and traffic patterns.	• Local cities and county agencies as appropriate • Caltrans • Others as appropriate	ATMS 1 ATMS 3 ATMS 7

Project #	Project Description	Participating Agencies	Market Packages Addressed
TM 7	Deploy projects for interoperation and coordination at agency boundaries, from not only a signal timing perspective, but also from an emergency vehicle pre-emption and transit signal priority perspective.	• MTC • Caltrans • Local cities and county agencies as appropriate • Transit agencies as appropriate • Local police and fire agencies as appropriate • Others as appropriate	APTS 7 EM 2
Traveler Information			
TI 1	Conduct projects to incorporate and integrate real-time transit information, roadway construction information, road weather information, arterial data, and other new data sources into the regional 511 System	• MTC • Others as appropriate	ATIS 1 ATIS 2 MCO 3 MCO 7
Public Transportation			
PT 1	Conduct a project to establish a common methodology to exchange automated vehicle location (AVL) data from transit vehicle systems of the various transit operators throughout the Bay Area region from a center-to-center perspective.	• Various Bay Area region transit operators	APTS 1
PT 2	Implement transit vehicle (bus and rail) emergency notification systems that enable emergency communications between the transit vehicle and the transit operations system and other centers.	• Various Bay Area region transit operators • Others as appropriate	APTS 5
PT 3	Implement transit signal priority in selected locations and along key transit corridors, as appropriate, throughout the Bay Area region. This project is a placeholder for any agency (local or state) seeking this type of deployment.	• Transit operators as appropriate • Subregional Local Cities-Counties • Caltrans • Others as appropriate	APTS 7

Project #	Project Description	Participating Agencies	Market Package(s) Addressed
Emergency Management			
EM 1	Deploy a regional system to allow emergency response vehicles and agencies to communicate with each other in the field.	• MTC • CHP • Caltrans • Local police and fire agencies • Others as appropriate.	ATMS 8 EM 1
EM 2	Conduct a project to integrate the CHP 911 Call Center Dispatch with external entities, as appropriate, in order to automatically exchange incident information.	• CHP • FSP • SMART Corridor partner agencies as appropriate • Local Police and Fire agencies as appropriate • Others as appropriate	ATIS 1 ATIS 2 ATMS 8 EM 4 EM 1
EM 3	Conduct a project to develop system interconnects from the Bay Area Incident Response System (BAIRS) to the following Bay Area region systems/stakeholders: Caltrans transportation management system, Caltrans maintenance vehicles, the various SMART Corridors, Local City-County Police and Fire systems, Local City-County traffic operations systems, CHP CAD system, Freeway Service Patrol (FSP, 911 call answering centers, 511 and TravInfo traveler information systems and others as appropriate.	• Caltrans • SMART Corridor partner agencies • Local Police and Fire agencies as appropriate • CHP • MTC • Others as appropriate	ATMS 6 ATMS 8 EM 1 ATIS 1 AD 2

Project #	Project Description	Participating Agencies	Market Package(s) Addressed
EM 4	Implement emergency vehicle preemption in selected locations and along key corridors, as appropriate, throughout the Bay Area region. To be used for standardized deployment throughout the region.	• Subregional Local Cities-Counties • Caltrans • SMART Corridor partner agencies • Local City-County Police and Fire agencies as appropriate • CHP • MTC • Others as appropriate	EM 2
EM 5	Deploy automated vehicle location (AVL) systems on emergency vehicles throughout the Bay Area region. To be used for standardized deployment throughout the region.	• Subregional Local Cities-Counties • Local City-County Police and Fire agencies as appropriate • CHP • MTC • Others as appropriate	EM 1 EM 2 EM 4

11.0 Regional Perspectives

In the course of developing the Regional ITS Architecture for the Bay Area, there were items that surfaced as important to mention as part of an overall Plan that did not necessarily fit into the format prescribed by the National ITS Architecture guidance. The Maintenance Team, as discussed in Section 13.2, should be responsible for prioritizing these actions and identifying lead agencies and resources, if appropriate. This list of action items is not meant to imply obligated funding to proceed. Proceeding with these actions will be the result of decisions made in the future during project planning processes.

11.1 Focus Areas

The following are areas of interest that were discussed by the stakeholders during the development of the Bay Area Regional ITS Architecture. Additional investigation of the following should be undertaken to determine if the project concept can help address regional problems. If the project concept can help address a regional problem, then it will be incorporated into the next update of the ITS Architecture as well as the corresponding Regional Operations Strategy (ROS).

- **Action Item #1, Regional Signal System Assessments:** Conduct a project to assess regional signal systems to determine which ones are in need of coordination or implementation of advanced strategies such as implementation of cameras or electronic signs. Determine if regional guidance or standards or other technical areas would be beneficial.

- **Action Item #2, New Technologies for Arterial Traffic Management:** Assess the need for and costs of the regional deployment of traffic management-related systems such as red light violation camera detection systems, parking management systems, and intersection collision avoidance systems.

- **Action Item #3, Multi-Modal Trip Planning Assessment:** Assess the need for and costs of a multi-modal trip planning capability in the 511 Personal Information Access and Web-page System for use by the general traveling public.

- **Action Item #4, New Traveler Information Interface Assessment:** Study the need for new interfaces from new traffic management systems to TravInfo®, the Media, Research Institutions, and other Information Service Providers (public and private) for the purpose of developing and disseminating traveler information. Determine if regional guidance or standards or other technical areas would be beneficial.

- **Action Item #5, Regional Transit ITS Working Group:** Facilitate the formation of a regional Transit ITS Working Group or common transit forum to exchange ITS lessons learned, challenges, and project information.

- **Action Item #6, Regional ITS O&M Guidelines:** Develop Bay Area specific information related to on-going ITS operations, including maintenance, benefit/cost, and evaluation procedures.

- **Action Item #7, Multi-Purpose Regional Fare Assessment:** Assess the regional consumer interest in a multi-purpose regional fare/toll collection technology for co-usage purposes, such as parking, small purchases, entry-exit control and infrastructure security. Determine if regional guidance or standards or other technical areas would be beneficial.

- **Action Item #8, Regional Technologies & Standards Assessment:** Assess the technologies and standards that would be applicable for the following projects: transit scheduling interfaces, closed circuit television cameras, roadside detection services, transit automatic vehicle location, and radio interoperability.

- **Action Item #9, DATEX to XML Evolution Assessment:** Investigate and assess the need for and the impacts of evolving from DATEX to XML for center-to-center data exchange.

Much interest was expressed by stakeholders with regard to ITS standards activities. But since many ITS standards are not yet ratified and there are no current FHWA suggestions for regional implementation, the Bay Area could perform activities to continue with development of a regional standards strategy. These efforts could include:

- **Action Item #10, Prioritization and Development of Customized ITS Standards for Bay Area Interfaces**: Many NTCIP standards include characteristics that are left in a "to be determined" state for the individual developer to customize during project implementation. The Bay Area would benefit from performing an activity/study to first discern the high priority Bay Area interfaces and

then make the decisions on the customizable elements of the relevant standards for use by regional agencies. Examples of some high priority interfaces include those that support traffic management, incident notification, and traveler information.

- **Action Item #11, Development of Interface Control Documents for Key Information Flows**: An interface control document (ICD) provides highly detailed information on the content, format, size, and other characteristics of specific information flows. Development of an ICD for key Bay Area information flows, such as those under development in SMART Corridor Projects, can be re-used for other projects and could benefit many agencies.

- **Action Item #12, Creation of a Regional Standard for Location-Based Data**: The Bay Area would also benefit by conducting a study to determine a common frame of location-based referencing so that communications between systems can be rationally reduced to an unambiguous reference to the same transportation links, ramps, intersections, etc.

- **Action Item #13, Formation of a Regional Standards Repository**: Once customized standards are created for the Bay Area, a central repository may be useful as the regional "keeper" of the information. A study to assess the need for this repository, to investigate what other regions are doing in this area, and to interpolate, for Bay Area benefit, the direction emanating from the National ITS Standards activities should be conducted.

- **Action Item #14, Development of a Regional Migration Plan to ITS Standards and Location Referencing Conformance**: This activity would provide guidance to existing/legacy projects and systems on evolution from their current interface definitions and methods to the regional, customized standards.

11.2 Architecture Project and Action Item Logical Sequencing

The act of project sequencing takes into account deployment timelines and dependencies. Project dependencies were used to identify project elements that must be implemented before other projects can begin. By applying dependencies, an efficient sequence can be developed so that projects incrementally build on each other, saving money and time as the Bay Area invests in future ITS deployments.

Other considered dependencies included:

- Where an ITS project deploys a system, there may be a study that needs to occur to establish or facilitate a policy and/or procedure before that system deployment can move forward.

- Where an ITS project implements information flows between systems, there may be an information dependency between the project that generates the information and the project that receives the information.

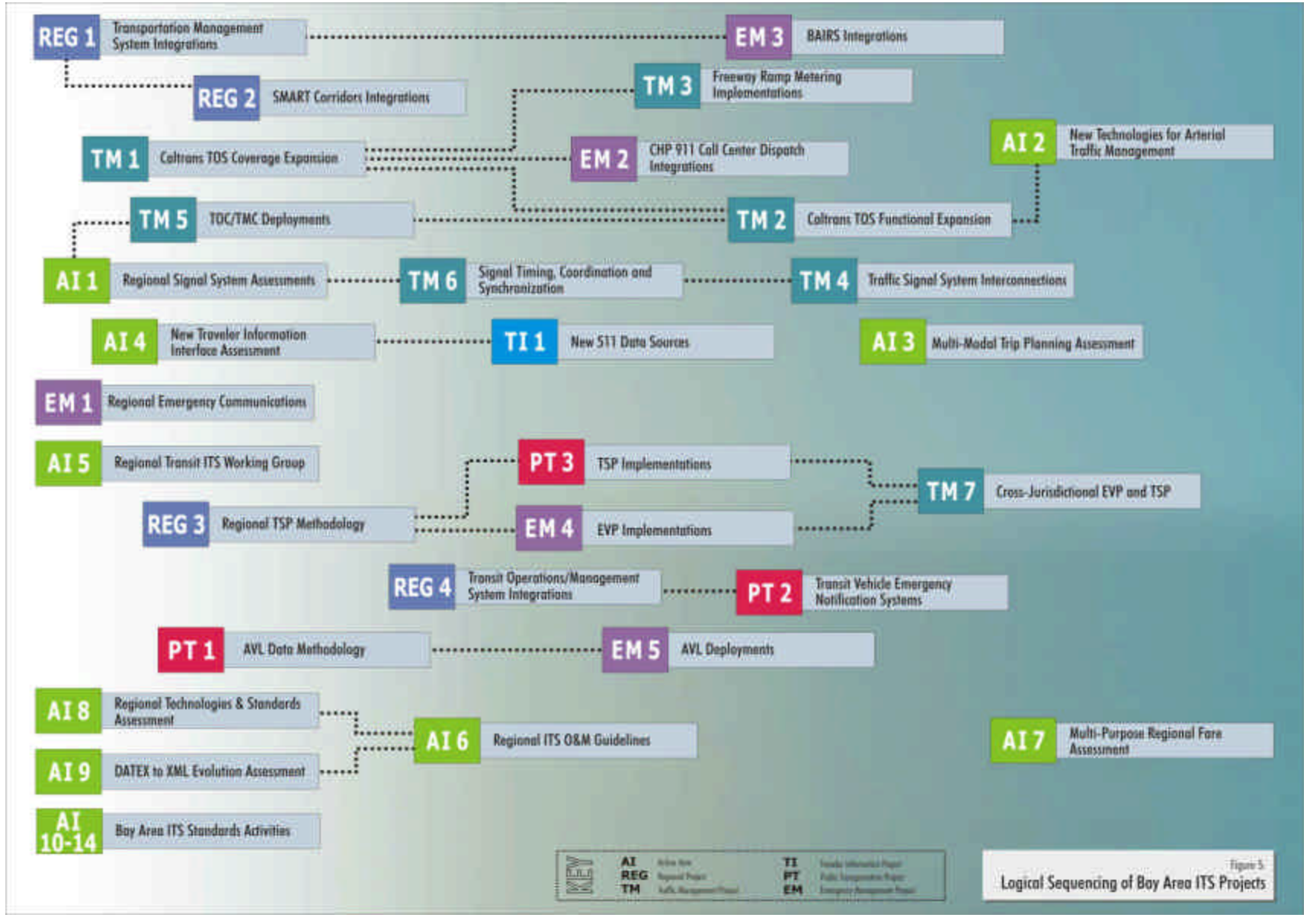
- Where an ITS project implements related functions on the same system, there may be a functional dependency between the two projects. For example, certain core functions (e.g., surveillance) must be implemented before more advanced functions (e.g., incident verification).

ITS projects could also be dependent on many other factors including the data or policy decisions that support the projects. For example, transit applications may benefit by waiting for the development of a regional Automatic Vehicle Location (AVL) formatting standard. Certain project deployments may

benefit by the needed results from a study on costs and benefits. Other system integration projects may require a ratified national standard. These types of dependencies have been recognized and factored into the project sequence.

The project sequencing diagram is presented in Figure 5. This diagram also accounts for non-architecture action items as presented in this section. What is not included in Figure 5, however, are all the existing ITS. Existing systems should not be overlooked in considering the sequencing and funding for future projects or action items. Operating and maintaining existing ITS will most often have a higher priority for future funding than will implementing a new initiative.

Figure 5: Logical Sequencing of Bay Area Bay Area Projects



12.0 Agency Agreements

Agreements among the different stakeholder agencies and organizations in the Bay Area may be required to realize the integration proposed in the regional ITS architecture. Each connection between systems in the regional ITS architecture represents cooperation between stakeholders and a potential requirement for an agreement.

Typically, existing stakeholder agreements that support sharing of information, funding, or specific ITS projects are reviewed and assessed to determine if they can be extended and used to support the cooperative implementation and operation of ITS. Assumptions have been made on the existence of agreements for providing current services. The list of the required Bay Area agreements was developed based on the regional operational concepts, knowledge of the types of ITS existing or planned for implementation by the region, and the information that needs to be exchanged in order to operate those systems.

12.1 Types of Agreements

There is considerable variation between regions and among Stakeholders regarding the types of agreements that are created to support ITS integration. The FHWA Regional ITS Architecture Guidance Document presents some common types of agreements, as noted in Table 9:

Table 9: Agreement Types (from FHWA Regional ITS Architecture Guidance Document)

Type of Agreement	Description
Handshake Agreement	• Early agreement between one or more partners • Not recommended for long term operations
Memorandum of Understanding (MOU)	• Initial agreement used to provide minimal detail and usually demonstrating a general consensus • Used to expand a more detailed agreement like a Interagency Agreement which may be broad in scope but contains all of the standard contract clauses required by a specific agency • May serve as a means to modify a much broader Master Funding Agreement, allowing the master agreement to cover various ITS projects throughout the region and the MOUs to specify the scope and differences between the projects
Interagency Agreement	• Between local public agencies (e.g., transit authorities, cities, counties, etc.) for operations, services, or funding • Documents responsibility, functions and liability, at a minimum
Intergovernmental Agreement	• Between governmental agencies (e.g., agreements between State DOTs, MPOs, etc.)
Operational Agreement	• Between any agency involved in funding, operating, maintaining or using the right-of-way of another public or private agency • Identifies respective responsibilities for all activities associated with shared systems being operated and/or maintained
Funding Agreement	• Documents the funding arrangements for ITS projects (and other projects) • Includes at a minimum standard funding clauses, detailed scope, services to be performed, detailed project budgets, etc.

Type of Agreement	Description
Master Agreements	• Standard contract and/or legal verbiage for a specific agency and serving as a master agreement by which all business is done and can be found in the legal department of many public agencies • Allows states, cities, transit agencies, and other public agencies that do business with the same agencies over and over (e.g., cities and counties) to have one Master Agreement that uses smaller agreements (e.g., MOUs, Scope-of-Work and Budget Modifications, Funding Agreements, Project Agreements, etc.) to modify or expand the boundaries of the larger agreement to include more specific language

12.2 Agreement Focus

Rather than focus on a specific technology in an agreement, the focus usually is on the scope-of-service and specific agency responsibilities for various components of the service. The agreement should also describe the high-level information that each agency needs to exchange in order to meet the goals and expectations of the other rather than defining how the delivery of that information will occur.

A simple handshake agreement may be enough for some Bay Area activities. But, once interconnections and integration of systems occur, agencies may want to have something more substantial in place in order to document items such as how operations will occur and who will maintain the system. A documented agreement will aid Bay Area agencies in planning their operational costs, understanding their respective roles and responsibilities, and in building trust for future projects. Formal agreements are necessary where funding or financial arrangements are defined or participation in large regionally significant projects is required.

12.3 List of Agreements

Table 10 presents a list of potential agreements. Each entry is first categorized by the ITS service delivery area. Then the involved stakeholders, the type of agreement that is anticipated, the high-level status, and a description of the purpose of the agreement are identified. Eventually, a 7th column should be added to the table during architecture maintenance cycles documenting any issues or barriers to agreement execution as potential starting points for negotiation.

Table 10: List of Agreements

ITS Service	Involved Stakeholder	Type of Agreement	Status	Agreement Description	Bay Area Examples, if any
Interjurisdictional Traffic Management	Caltrans D4, other adjacent Caltrans districts, CHP, and other Bay Area TMCs, MTC	Interagency Agreement	May exist in some form which could be amended	Provides for data exchange and device control and details jurisdiction-to-jurisdiction operations and regional incident management.	SMART Corridor Agreements, Agreement with Caltrans for Deployment of ETC Readers
Regional Traffic Management and Emergency Services	Caltrans and Local Cities and Counties and Emergency Services Providers	Memorandum of Understanding	New, not pre-existing	Provides for signal operations and coordination and local incident management.	
Emergency Vehicle Signal Pre-emption	Caltrans and/or Local Cities and Counties and Emergency Services Providers	Interagency Agreement	New, not pre-existing	Documents details on roles, responsibilities, and functions for emergency vehicle pre-emption at signalized intersections within a city for police, fire, ambulance, or other agency.	
Transit Signal Priority	Caltrans and/or Local Cities and Counties and Transit Agencies	Interagency Agreement	New, not pre-existing	Documents details on roles, responsibilities, and functions for transit vehicle priority at signalized intersection within a city for a transit agency.	

ITS Service	Involved Stakeholders	Type of Agreement	Status	Agreement Description	Bay Area Examples, if any
Freeway Service Patrol	MTC, Caltrans, and CHP	Interagency Agreement	Exists	Documents details on roles, responsibilities, and functions for providing freeway service patrol activities.	
Transit Fare Management	All Transit Agencies (TransLink)	Interagency Agreement	Exists	Provides details on the usage of a common regional fare card and the cost allocation formulas.	TransLink Interagency Participation Agreement
Traveler Information	All Agencies and Information Service Providers (media)	Memorandum of Understanding	May exist in some form which could be amended	Documents expectations, roles, and responsibilities for the provision of transportation-related data and information to the traveling public. Also, documents the policy or disclaimer for release of traveler information.	Data Disseminator Agreements, CT/CHP/MTC MOU for TravInfo & ITS
Archived Data Management	All Agencies and PeMS	Memorandum of Understanding	New, not pre-existing	Documents expectations, roles, and responsibilities for the dissemination of transportation-related data and information for archive purposes.	
Commercial Vehicle Operations Administration	To be addressed outside of region	Not applicable	Not applicable	Not applicable	

ITS Service	Involved Stakeholders	Type of Agreement	Status	Agreement Description	Bay Area Examples, if any
Cross-Cutting (shared use of fiber infrastructure)	Multiple agencies	Interagency Agreement	New, not pre-existing	Documents provisions for design, development, maintenance, and revenue sharing (if applicable) with regards to shared use of fiber.	

13.0 Use and Maintenance of the Architecture

The success of the Bay Area Regional ITS Architecture is dependent upon effective use of the architecture once it is completed. The architecture should be mainstreamed into the planning and deployment processes for the region and should become a tool for stakeholders to use in planning their projects to support regional goals.

There are two critical times to use a regional ITS architecture. The first instance is to assist in the traditional transportation planning process that occurs within MTC and all other local and regional planning organizations. The other critical time is in design and implementation/deployment of regional ITS projects.

In order to get the most out of regional architecture, this section introduces and expands on specific planning processes that already exist and how the Bay Area Regional Architecture will be maintained to support those processes in the future.

13.1 Using the Bay Area Regional ITS Architecture

A typical ITS project life cycle involves processes related to planning, design, procurement, and deployment. The regional ITS architecture plays a role in each of these phases, as outlined below.

13.1.1 In Planning

The goal of the regional transportation planning process is to make informed decisions on the investment of public funds for regional transportation systems and services. The regional outputs of the transportation planning process are, basically, two regional plans:

- The Regional Transportation Plan (RTP) is a long-range plan with a horizon of at least 20 years and is updated every few (usually three) years.
- The Regional Transportation Improvement Program (RTIP), which is a short-term funding program that usually gets updated annually. Projects must be included in the RTIP and the RTP in order to receive federal funding.

The regional ITS architecture is a single source summarizing the existing and planned ITS projects in the region. Project sponsors should use the brief project description(s) in Table 8 of this document as a starting point in submitting a placeholder for the project of interest in the RTP/RTIP. Project sponsors also need to review and follow, if appropriate, the procedures as outlined in Chapter 12.6 of the Caltrans Local Assistance Program (LAP) Guidelines. Caltrans has amended their LAP Guidelines to take ITS projects into account. ITS projects receiving federal funding now have additional requirements to ensure that a system engineering process is followed, especially for major federally-funded ITS projects.

One requirement of the LAP guidelines is that the local agency must detail how the proposed project fits into the regional ITS architecture. Specifically, Step 9 of the LAP process for ITS Projects asks the project sponsor to submit a Systems Engineering Review Form (SERF). The list below shows where in the regional ITS architecture documentation some of these SERF requirements can be found. Most of these requirements focus on Center-to-Center system connections. Smaller localized, non-regional, and / or non-interagency projects do not fall into this category.

SERF Requirement	Regional ITS Architecture Resource
a) Identification of portions of RA being Implemented	Appendix C: Bay Area ITS Inventory, or Table 8: Regional Bay Area ITS Projects
b) Identification of participating agencies roles and responsibilities	Table 6: Bay Area Operational Concepts
c) Requirements definition	Section 7: Functional Requirements
d) Analysis of alternative system configurations and technology options to meet requirements	Not Available in Regional ITS Architecture
e) Procurement options	Not Available in Regional ITS Architecture
f) Identification of applicable ITS standards and testing procedures	Appendix H: Detailed Listing of NTCIP Standards for the Bay Area (Testing Procedures not available)
g) Procedures and resources necessary for operations and management of the system	Not Available in Regional ITS Architecture

Refer to http://www.dot.ca.gov/hq/LocalPrograms for additional information.

13.1.2 In Project Development and Design

The regional ITS architecture assists in defining high-level requirements in ITS design for specific project development. Because consensus is a critical part of regional ITS architecture development, regional architecture serves as a source for defining regional projects by simply referring to the project list in Table 8 of the regional ITS architecture.

During project development, stakeholders should incorporate regional ITS architecture elements such as operational concepts, standards, and functions in their detailed design documents. This method of defining ITS projects for future deployment is consistent with the National ITS Architecture, it lends credibility to new projects, it limits duplicate efforts by transportation stakeholders, and it supports a uniform regional approach to both the planning and the deployment process.

For example, if an agency wanted to build a Traffic Operations Center for their signal system incorporating other ITS devices, such as CCTV cameras and electronic signs, the process would proceed

as follows (a similar process would be used if a transit system or a traveler information system or any other ITS project were of interest):

1. Consult the Regional ITS Architecture (this document) to see if the project had been previously captured under existing inventory in Appendix C or D or in the potential projects list from **Table 8**.
2. If the project has been included, then find the related:

    - Operational Concepts in **Table 6**
    - Functional Requirements in **Chapter 7**
    - System Interconnects and Information Flow Diagrams in **Appendix G**
    - Recommended and Appropriate Standards from **Appendix H**

3. Review these items and decide which interfaces and flows the current project must accommodate.
4. Contact the stakeholders referenced in the flow diagrams and coordinate the data to be exchanged and the standards to be used as a starting point.
5. Determine whether an agreement is required for the purpose of system integration and data exchange and other relevant terms. **Chapter 12** offers a list of potential agency agreements from which to start.
6. Review and submit all appropriate material as directed by Chapter 12.6 of the Caltrans Local Assistance Program (LAP) Guidelines.
7. Follow systems engineering process in project deployment. (If this process is unfamiliar, FHWA has support documentation and can provide training and guidance.)
8. Bring the project particulars before the Architecture Maintenance Team for assessment of consistency with the Regional Architecture, as noted in **Chapter 13**.

If the project has not been previously identified in the Regional Architecture, then a systems engineering process should be executed by the stakeholder to develop the items that modify the regional architecture, such as the services, operational concepts, functional requirements, system interconnects, agreements and information flows. Use the process detailed in **Section 13.2.4** of this report to inform the Architecture Maintenance Team of any updates/changes. It is up to the Architecture Maintenance Team in the region to determine whether this information would need to be modified immediately in the regional architecture or whether it could be incorporated into the Regional Architecture during a routine maintenance cycle.

13.1.3 In Procurement

The National ITS Architecture defines Equipment Packages to be physical architecture subsystems and groups similar processes of a particular subsystem together into an implementable package. The grouping also takes into account the user services and the need to accommodate various levels of functionality.

Since Equipment Packages are both the most detailed elements of the physical architecture view of the National ITS Architecture and tied to specific market packages, they provide the common link between the interface-oriented architecture definition and the deployment-oriented market packages.

Equipment Package descriptions were used in the derivation of the Bay Area ITS functional requirements. Each statement was functionally associated and contained information on what certain systems "shall perform" or "shall do". Stakeholders should use these descriptions when assembling the functional requirements for the procurement process.

In addition to the Equipment Packages, once a project is included in the Regional ITS Architecture, there are a number of reports and diagrams that can be printed using the Turbo tool that can be helpful in the procurement process, such as the interconnects and information flow diagrams. Also, the availability of

the standards document and the operational concepts from the Regional ITS Architecture are valuable tools for contractors and/or consultants to use during the procurement process in responding to a Request for Proposal (RFP).

13.1.4 In Deployment

The Bay Area ITS Architecture identifies, the information flows and regional services (i.e. Market Packages) desired by the region. The detailed databases resulting from Turbo are a valuable resource and can be cut and pasted when writing functional requirements for ITS deployments. These requirements then become traceable throughout the deployment process and can be tested during an acceptance phase for compliance with the planning and design efforts.

13.2 Maintaining the Bay Area Regional ITS Architecture

The Bay Area Regional ITS Architecture should be modified as plans and priorities change, ITS projects are implemented, and the ITS needs and services evolve in the region. The Bay Area ITS Architecture was developed with a ten-year time horizon. As the architecture is updated, it will be extended further into the future. The goal of maintaining the architecture is to keep an up-to-date regional ITS architecture that is accessible and easily used for deploying ITS in the San Francisco Bay Area.

What is the process by which the architecture is modified/changed? The key aspects of the maintenance process, which are defined in this section are:

- Who is responsible?
- What has to be maintained?
- When (how often) does this occur?
- How are changes identified?

13.2.1 Responsibility for Maintaining the Regional ITS Architecture

Just as a group of stakeholders were key to the development of the Bay Area Regional ITS Architecture, it is imperative that stakeholders stay involved in the on-going maintenance. Because changes can arise from many sources, and very likely will arise from sources outside the technical expertise of a single agency, it is a good idea for a group of people from different stakeholder areas to be involved in maintenance of the architecture. Representatives from traffic, transit, emergency management, and other key stakeholders should provide input to the maintenance process. It is recommended that a Bay Area Architecture Maintenance Team be developed that includes at least one representative from MTC, a Transit Agency, Caltrans D4, and a SMART Corridor Agency. It is recommended that MTC take the lead role with overall responsibility and accountability for the formal database and architecture maintenance.

13.2.2 Items to Maintain in the Architecture

The parts of a regional ITS architecture that need to be maintained are referred to as the "baseline" architecture. This section considers the different parts of the regional ITS architecture and whether they should be a part of the maintained baseline.

The Bay Area Regional ITS Architecture is stored in Microsoft Access databases and is represented through a set of outputs including reports and diagrams. To aid the Bay Area with architecture version document control, the filename of the database should contain the date on which the architecture was updated. This allows the most current version to be easily identified.

Outputs such as interconnect and information flow diagrams, inventory lists, stakeholder lists and other diagrams and reports can be produced by a member of the Maintenance Team from Turbo outputs as by-products of the architecture database. These outputs can be updated as necessary for meetings or outreach activities. The following are the components of the baseline regional ITS architecture that should be maintained.

Regional Description

Sections 3.1 and 3.2 of the Bay Area Regional ITS Plan describe the geographic scope and architecture timeframe. Geographic scope defines the region for which ITS elements the Plan should address, although additional ITS elements outside the region may be necessary to describe if they communicate ITS information to elements inside the region. Architecture timeframe is the time period (in years) into the future that the regional ITS architecture considers. The description of the region for the Bay Area ITS Architecture is contained in this document as noted above, is part of the baseline, and should be reviewed for changes whenever the Bay Area Regional ITS Architecture is updated.

Stakeholder Description

Stakeholders are key to the definition of the baseline architecture. Over time, stakeholder organizations may merge or separate, and such changes should be reflected in the architecture. Furthermore, stakeholders that have not been engaged in the past might be approached to confirm if the regional ITS architecture represents their ITS requirements well. The Bay Area stakeholders are described in Section 3.3 and Appendix B of this document and are also described in the Turbo database. Their listing and description are part of the baseline and should be updated during an architecture maintenance process.

List of ITS Elements

The inventory of ITS elements is a key aspect of the baseline regional ITS architecture and should be updated during an architecture maintenance process. Changes in stakeholders as well as operational concepts may impact the inventory of ITS elements. Furthermore, recent implementation of ITS projects may change the status of ITS elements (e.g. from planned to existing). The list of elements is contained in Appendices C and D of the Bay Area Regional ITS Plan and is also stored in the Turbo database.

Operational Concepts

It is crucial that the operational concepts (which are represented as roles and responsibilities) in a regional ITS architecture accurately represent the consensus vision of how the stakeholders want their ITS to operate for the benefit of surface transportation users. These should be reviewed and, if necessary, changed to represent what has been deployed (which may have been shown as "planned" in the earlier version of the regional ITS architecture). Many of the remaining maintenance efforts will depend on the outcome of the changes made here. The operational concepts are summarized in the Bay Area Regional ITS Plan in Table 6, are part of the baseline, and should be reviewed for changes whenever the Bay Area Regional ITS Architecture is updated.

System Functional Requirements

High-level functions are allocated to ITS elements as part of the regional ITS architecture. These can serve as a starting point for the functional definition of projects that map to portions of the regional ITS architecture. The details are included in the Bay Area Regional ITS Plan in Section 7, are part of the baseline, and should be reviewed for changes whenever the Bay Area Regional ITS Architecture is updated.

Interfaces between Elements (interconnects and information flows)

Interfaces between elements define the details of the architecture. They are the detailed description of how the various ITS systems are or will be integrated throughout the timeframe of the architecture. These details are presented in Appendix G to the Bay Area Regional ITS Plan and are also included in the Turbo database. They are a key aspect of the baseline architecture, and one that will likely see the greatest amount of change during the maintenance process.

List of Agreements

One of the greatest values of a regional ITS architecture is to identify where information will cross an agency boundary, which may indicate a need for an agency agreement. An update to the list of agreements can follow the update to the operational concept and/or interfaces between elements. A suggested list of agreements is found in the Bay Area Regional ITS Plan in Table 10. This listing should be a part of the baseline and should be reviewed for changes whenever the Bay Area Regional ITS Architecture is updated.

Applicable ITS Standards

The selection of standards depends on the information exchange requirements. But in addition, the maintenance process should consider how ITS standards may have evolved and matured since the last update, and consider how any change in the standards environment may impact previous regional standards choices (especially where competing standards exist). For example, if XML based Center-to-Center standards reach a high-level of maturity, reliability and cost-effectiveness, then a regional standards technology decision may be made to transition from investments in other standards technologies (e.g. DATEX to XML). The description of the standards environment for the region, as well as the details of which standards apply to the architecture, are held in the architecture document under Section 9. The Turbo database holds the details on the suggested standards for each information flow, a print-out is noted in Appendix H. Standards are part of the baseline and should be reviewed for changes whenever the Bay Area Regional ITS Architecture is updated.

Project Sequencing

While project sequencing is partly determined by functional dependencies (e.g. "surveillance" must be a precursor to "traffic management"), the reality is that for the most part project sequences are local policy decisions. ITS project selection and sequencing should be reviewed to make sure that they are in line with current policy decisions. Furthermore, policy makers should be informed of the sequences, and their input should be sought to make the project sequences in line with their expectations. This is crucial to prevent the regional ITS architecture from becoming irrelevant. The list of ITS projects and the logical sequencing is included in this document in Section 10, is part of the architecture baseline, and should be reviewed for changes whenever the Bay Area Regional ITS Architecture is updated.

13.2.3 Frequency for Updating the Architecture

It is recommended that this Bay Area Regional ITS Architecture report become an appendix to the RTP. When the RTP undergoes a formal update – typically once every three years – the architecture should undergo any major modifications at that time. If the RTP changes its formal update frequency, the baseline ITS architecture update should adjust its schedule accordingly. This is a natural result of the architecture being streamlined into the regional planning process to ensure that the architecture continues to accurately represent the region.

The operational concept, system functional requirements, project sequencing list, and the list of agency agreements represent high-level views of the Bay Area Architecture and do not necessarily need to be modified each time a revision is made to the architecture. However, these architecture components should be modified as necessary to address new needs and services. The first architecture update will be substantial because there were major modifications to the National ITS Architecture and Turbo during the development of the Bay Area Regional Architecture that were not included (i.e., National ITS Architecture migrated an entire version from 4.0 to 5.0 as did Turbo Architecture from 2.0 to 3.0).

The Maintenance Team should determine the schedule that modifications can be submitted for inclusion into the Regional ITS Architecture but it is anticipated that there will be minor updates annually with a major update to occur once every three years.

13.2.4 ITS Project/System Update Process

Any stakeholder under the Bay Area Regional ITS Architecture can request/propose a change to the regional ITS architecture. Notifying the Bay Area ITS Architecture Maintenance Team of any modifications is the responsibility of the stakeholder agency that is implementing the project. To properly maintain the architecture, the Maintenance Team should be informed not only of when projects are planned, but also when projects are completed or when changes made during design or construction impact the regional architecture.

Stakeholders should propose changes in writing to the Maintenance Team and should be prepared to submit any modifications that are being requested in writing with documentation of any architecture interconnect and flow modifications. Proposals should clearly define the architecture aspects to be added, deleted or revised. The reasons for proposed modifications should be given. Each proposal should include contact information for the person proposing the change so he or she can be contacted if questions arise.

The architecture project website at www.iteris.com/mtcits has been modified to contain a section called "Architecture". This website page contains a form for Bay Area Stakeholders to submit updates and changes on-line. (Note that the project website will move to the MTC public website in the future – http://www.mtc.ca.gov/.)

The form includes fields for the stakeholder to enter the following:

- Agency name
- Contact name
- Brief description of proposed update
- Does the proposed change add an element(s) the Regional Architecture or modify an existing element(s) in the Regional Architecture, or both?

- Name of system(s) being implemented or modified
- Project/System Status:
    - Proposed (the agency wants to implement but has not yet secured funding for the proposed project)
    - Planned (the agency has secured funding for the project)
    - Under construction (the agency is currently deploying the system)
    - Existing (the agency has deployed the system(s) and it is currently operational)

The form will then be emailed, in a simple text email format to an email address at MTC as part of their Maintenance Team activities. Each proposed modification will be reviewed and considered by the Maintenance Team who, at the same time, will consider timing issues as they relate to the RTP and RTIP approval update process.

If the proposal for architecture modification has an impact on other stakeholders, a Maintenance Team representative will contact the stakeholders to confirm their agreement with the modification. If warranted, a stakeholder meeting to discuss the modification may be held. If consensus in favor of the modification is reached, the Maintenance Team member identified as the "keeper of the databases" would make the revision in the architecture database.

Once the regional architecture has been modified, the stakeholders in the region should be notified. The Maintenance Team should maintain a list of stakeholders and their contact information. The stakeholders should be notified of architecture updates in writing via email and informed on how to obtain the latest version of the architecture.

13.3 Suggested Bay Area ITS Architecture Updates

An ITS Architecture is designed to be a dynamic tool, and so was the case during the development of the baseline Regional ITS Architecture for the Bay Area. Update items continued to be submitted to the project team, even when the project timing required these items to be filed away for incorporation in a subsequent Maintenance Phase. A list of those items is noted in Table 11 for the sake of the Bay Area Maintenance Team and for safekeeping until such time as the next architecture update occurs.

Certain items from Table 11 merit further explanation, including the National ITS Architecture and Turbo Architecture upgrades, connections and information flows to adjacent counties and to Southern California systems, and the influence of the Statewide ITS Architecture. Each is described below.

National ITS Architecture Upgrade. In the fall of 2003, a new version of the National ITS Architecture, Version 5.0, was released to the public. With Version 5.0, there were significant modifications and changes to the National ITS Architecture. Many of the changes in Version 5.0 are impacted by security and emergency management using ITS technology in emergency situations (i.e., evacuation, homeland security, etc.) and many of these changes were brought about by the national priority of securing transportation infrastructures. The list of items of the baseline architecture impacted by Version 5.0 is provided in Appendix I. The first scheduled maintenance or update of the Bay Area Regional ITS Architecture should address the conversion to Version 5.0 of the National ITS Architecture.

Turbo Architecture Upgrade. Since there were so many significant changes in the National ITS Architecture, a major version change to Turbo followed. Turbo is an interactive software application that assists transportation planners and system integrators, both in the public and private sectors, in the development of regional and project architectures using the National ITS Architecture as a starting point. It is also the tool that was used to develop reports and diagrams for the Bay Area Regional Architecture.

The Bay Area ITS Architecture was created using Turbo V.2.0. Turbo Version 3.0 was released in April 2004. It is suggested that the first maintenance update of the Bay Area Regional ITS Architecture be updated to Turbo 3.0. A brief summary of the differences between Version 2.0 and Version 3.0 of Turbo are listed in Appendix J.

Connections and Information Flows to Adjacent Counties and to Southern California Systems. At this time, the system interconnects and information flows to the adjacent counties beyond the Bay Area or to other regions in California have not been addressed by this regional ITS architecture. This is a crucial aspect to eventually be planned, assessed, designed, and implemented. However, the Bay Area stakeholders should defer to the current Statewide ITS Architecture activity to produce a direction for this region-to-region integration.

Statewide ITS Architecture As mentioned, an effort is underway to develop a statewide ITS architecture, which pulls all of the regional architectures together at a high-level to represent the state as a whole. This effort will not be redundant to the regional efforts, but instead focuses on those services that are provided at a statewide level. This includes Commercial Vehicle Operations, region-to-region interconnects, archived data management, and certain services related to rural areas not previously addressed by other regional architectures. The Bay Area regional ITS architecture does not go into great detail in these areas and defers to the statewide effort for guidance and direction.

Table 11: Proposed Updates to the Bay Area Regional ITS Architecture

Stakeholder	Type of Change	Description
AC Transit	add system	Bus Rapid Transit (BRT) Service
Alameda County CMA	add system	East Bay Smart Corridor Program Transit Signal Priority (TSP) Deployment in Oakland and Emeryville (of 60 intersections involved, 25 are Caltrans signals)
BAIRS	modify flow	Delete information flow to media. Add flow of vehicle location from FSP.
BART	add system	Parking Application (common ticket for parking and BART fare)
BART	add system	Long Term Parking
Bay Area	upgrade	National ITS Architecture upgrade to Version 5.0
Bay Area	upgrade	Turbo Architecture Upgrade to Version 3.0
City of Berkeley	add system	Parking Facility Management (wayfare system to provide status signing at major gateways to the City and along routes to the downtown/University area)

Stakeholder	Type of Change	Description
California Highway Patrol	modify interconnects	From CHP Vehicles, remove the environmental probe data flow to the CHP CAD. From CHP CAD, remove the road network probe information flow to MTC, TravInfo, Regional Archive System, Caltrans BAIRS, and Caltrans D-4 Transportation Management System. Remove Remote Surveillance Control from the CHP 911 Call Center to the Alameda County Congestion Management Agency East Bay SMART Corridor ATMS, City of Antioch SR4 East SMART Corridor ATMS, City of Concord - Concord, Walnut Creek, Pleasant Hill SMART Corridor ATMS, City of Pleasanton I-580 SMART Corridor ATMS, and City of San Jose Silicon Valley SMART Corridor ATMS.
City of Oakland	modify interconnects (as appropriate, consistent with the regional architecture)	Add City of Oakland direct connect to CHP CAD Add City of Oakland direct connect to CT D4 Roadside Equipment Add City of Oakland direct connect to CT D4 TMC
City of Oakland	add system	Oakland Airport Area ITS Project: This project would involve installation of CCTV cameras, vehicle detectors, dynamic message signs, transit priority, real-time traveler information displays, etc. to improve management of the corridors leading to/from OAK and the I-880/Coliseum area. This project would interconnect the signals along these routes to minimize delay and improve traffic flows, and provide the Port and City with centralized control for incident management. Real-time traffic-responsive systems would be considered.
City of San Jose	add system	International Airport Advanced Transportation Management System (ATMS)
Metropolitan Transportation Commission	modify interconnects and flows to TravInfo	Delete plans for yellow pages functionality. Delete plans for fare or price info functions. Delete connections to all transit operations systems.
Metropolitan Transportation Commission	add / modify interconnects and flows between the Bay Area Architecture and other adjacent architectures	Address, as appropriate, the system interconnects and information flows to the adjacent counties beyond the Bay Area or to other regions in California that have not been addressed by this regional ITS architecture.

Stakeholder	Type of Change	Description
Metropolitan Transportation Commission	add / modify interconnects and flows between the Bay Area Architecture and the statewide architecture	Address, as appropriate, the system interconnects and information flows to the statewide architecture that have not been addressed by this regional ITS architecture.
Port of Oakland	add system	This project will construct the infrastructure and variable message boards at three locations en route to the Port's maritime facilities. It is assumed that the Central Communications Center will be located at a facility in the Maritime Support Center area.
SAMTRANS	add system	Vehicle Safety Project (collision avoidance)
San Francisco Airport Authority	add system	People Mover
San Francisco DPT	add system	Parking Meter Modernization Program (electronic data uploaded to DPT management system)
Santa Clara County	add systems	Light Rail Transit Signal Priority System, Flood Watch System
Santa Clara VTA	add system	Bus Rapid Transit (BRT) Program

The following list of Appendices are offered in separate electronic files.

- Appendix A: List of Acronyms
- Appendix B: List of Stakeholders
- Appendix C: Bay Area ITS Inventory (sorted by stakeholder agency)
- Appendix D: Bay Area ITS Inventory (sorted by architecture entity)
- Appendix E: Bay Area Market Package Descriptions
- Appendix F: Bay Area ITS Inventory and Market Packages
- Appendix G: Interconnects and Information Flows (offered as a separate document)
- Appendix H: Detailed Listing of NTCIP Standards for the Bay Area (offered as a separate document)
- Appendix I: National ITS Architecture Updates
- Appendix J: Turbo Architecture™ Updates